DISCOVERY

Monthly Notebook
DAVID S. EVANS
M.A., Ph.D., F.Inst.P.

Dr. L. H. Lampitt
WILLIAM E. DICK

Cosmic Rays
MALCOLM McCAIG,
Ph.D., F.Inst.P.

Ozone in the Air we Breathe
J. L. EDGAR, B.Sc., Ph.D.

Gasification of Coal Seams

Surgery of the Brain in Peace and War

A Scottish Railway Epic
LORD MONKSWELL

Night Sky in June
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Junior Science

The Bookshelf

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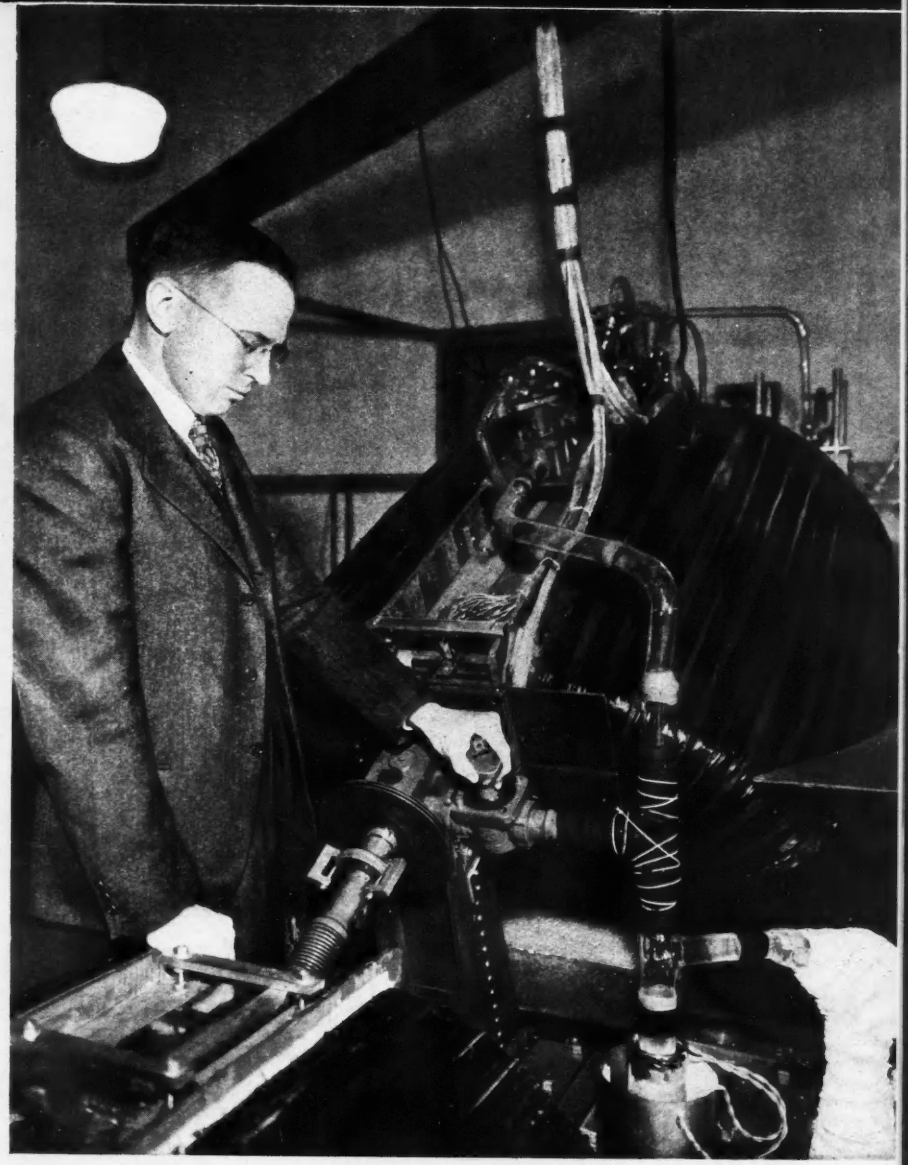

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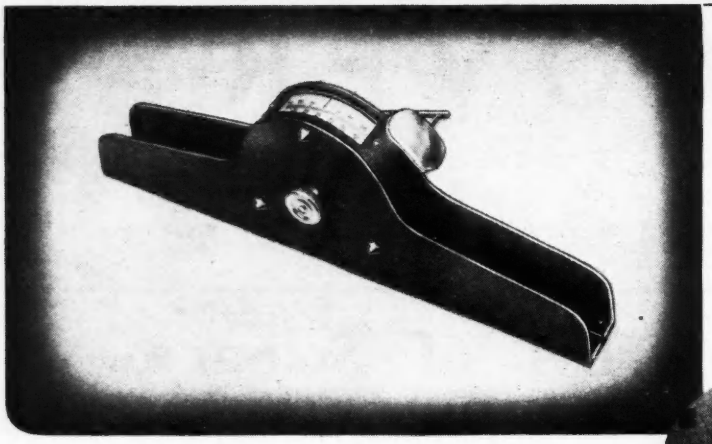

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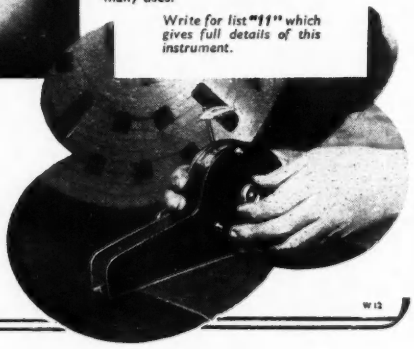

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The Progress of Science

A MONTHLY NOTEBOOK COMPILED UNDER THE DIRECTION OF DAVID S. EVANS

Science in Parliament

THERE have been occasions in the past when it was certainly possible to criticise the discussions on scientific subjects which took place in the House of Commons; when there was a lack of appreciation of the essential factors involved in the application of scientific knowledge, and even an unbecoming frivolity in the discussion of important scientific issues. However, when we turn to the reports of the Debate on the Amendment moved by Sir Granville Gibson on April 19th we find an entirely different state of affairs. Sir Granville moved:

> "That this House, recognising the vital part which research and science and their effective application can play in reconstruction, as a means of increasing our national prosperity, raising the standard of living, recovering our export trade and developing the national resources of our Empire, urges the declaration of a bold and generous Government policy of financial assistance directed to the expansion of teaching and research facilities in our universities and technical colleges, to the extension of pure and applied research in all fields by the State, by industry through private firms and research associations and to the effective and rapid application of the results of research."

Truly a motion with something in it for everyone, and the House rose to the occasion and discussed it with a wonderful display of expert knowledge and experience. The Debate occupied a whole day and ranged over every aspect of scientific research and its applications. It is certainly worth reading in full, and the issue of Hansard containing the debate was sold out in 24 hours. Any commentary on so extensive a discussion must naturally confine itself to particular selected topics.

The most striking thing of all was that no member who spoke evidenced the slightest doubt of the urgent necessity of increasing the volume and facilities of scientific research in this country. Recent events may cause us to wonder whether even the clearly expressed wishes of the House will be implemented by the Government, but it is to be hoped that on this important matter at least there will be no reversal of policy in the future. The able speech of the mover was filled with scientific examples and stressed the fact that the supremacy of Britain during the nineteenth century had more to do with the practical application of scientific knowledge in our industry than any policy of Free Trade or its converse. He called attention to the necessity of making use in this country of the scientific advances made by our own scientists. Classic examples of our own failure to implement scientific knowledge gained in Britain and consequent commercial injury are those of Perkin's discovery of synthetic dyes and Mushet's discovery of high-speed steel, both of which were, so to speak, exported to Germany and developed there with no benefit to the country of origin.

He might perhaps have cited a more modern example. The discovery of the bacteriostatic properties of penicillin and its development into an agent for therapeutic use, is the result of the magnificent team work of a group of British scientists, of whom Professor H. W. Florey is the best known. However, the impression one gains from a general study of published material both in this country and elsewhere is that much greater progress towards commercial production has been achieved abroad and particularly in the United States. Are we perhaps witnessing yet another instance of the export of valuable knowledge due perhaps to the inability of the British chemical industry to adapt itself sufficiently readily to new technical processes? In this case of course it ought to be a matter for rejoicing that the task should fall to that member of the United Nations best fitted to undertake it, but the fact itself is of interest, particularly in view of the remark made by Mr. Wootton-Davies—himself a chemical manufacturer—during the course of the Debate. He gave an instance of the case of the supply of an acetic acid and artificial silk plant valued at £1,000,000 to India, which will be supplied from the United States because of a lack of co-operation on the part of those who might have supplied it from Britain.

It was evidently felt that there was some reluctance even now on the part of British industry to make full use of science. The discussion of financial measures such as the

possibility of large income-tax rebates, the buying-up and suppression of patents and similar matters, support this idea.

Of the finance of the individual scientists many members spoke. It was clearly felt and many times expressed that scientists were inadequately paid, that the best men could not be attracted into the profession and that something badly needed doing; Mr. Harvey quoted the statement that "members of science and medical faculties are ill-paid and over-employed with teaching and sometimes routine duties. The burden of teaching compared to the Arts standard is overwhelming." Mr. Griffiths gave the example of nine B.Sc.'s in one works whose average salary was £5 17s. per week. Mr. Price said: "A great deal of invaluable work has been done in the discovery and development of radio-location by a large number of research students, working on grants of £120 per year from the Department of Scientific and Industrial Research." Sir Granville Gibson quoted unfavourable comparisons of the salaries of research workers with those of teachers and of semi-skilled workers. Other speakers contrasted their pay and promotion unfavourably with those of corresponding grades in the civil service.

Mr. Salt got down to the brass tacks of big finance. He asked for possibly £20 million over twenty years for capital expenditure for the universities, and an increase in the annual grant from £2,250,000 to £6,000,000 or £7,000,000. This expenditure would be needed to provide for the training of possibly double the present volume of scientific personnel and the provision of equipment and buildings and proper salaries for staffs, as well as increased financial provision for fundamental research which finds its chief seat in the universities. All this was very admirable and found strong support from speakers such as Sir George Schuster, who wanted an increase both in the numbers of scientific workers and in the scientific content of the education of ordinary workers. He quoted a statement of Sir Robert Watson Watt's: "The scientific method must pervade all stages of production and all stages of the use of the product. The scientific worker must live with the maker and the user." If there is any ground for criticism of the Debate it is to be found in the attitude of some of the members to the actual conditions of scientific work. Mr. Price, for example, quoted the statement that only one person in a million turns out a first-class physicist and continued as if the whole store of ability were tapped. It is extremely doubtful whether this is true. All that we can say, to put it carpingly, is that in spite of present conditions one person in a million becomes a first-class physicist. With better educational facilities we might get many more. However, that is a rather minor point. In spite of exceptions such as Sir George Schuster, who again quoted Sir Robert Watson Watt as saying that one of the most important features of modern scientific work was "sustained team effort", there is a general tendency to stress the idea of the brilliant single individual. Even now there does not seem to be a general recognition of the fact that team research has come to stay, especially in connection with really big projects which have to be followed perhaps through three or four different sciences before they are brought into full application. All the big advances of this war—operational research, radio-location, penicillin and so on are team projects—and it is a pity that this is not more widely recognised. Even Sir John Graham Ker in the debate on the Health White Paper fell into this error and described penicillin as if it were the outcome of the efforts of a single individual. In the present debate there were several examples of this.

Lastly another dangerous misconception was voiced by Mr. James Griffiths when he said that the war had given a great impetus to fundamental research. This is quite untrue—when the war ends there will be years to be caught up in the field of fundamental research which during the war has had to be shelved in order to produce urgently needed applications.

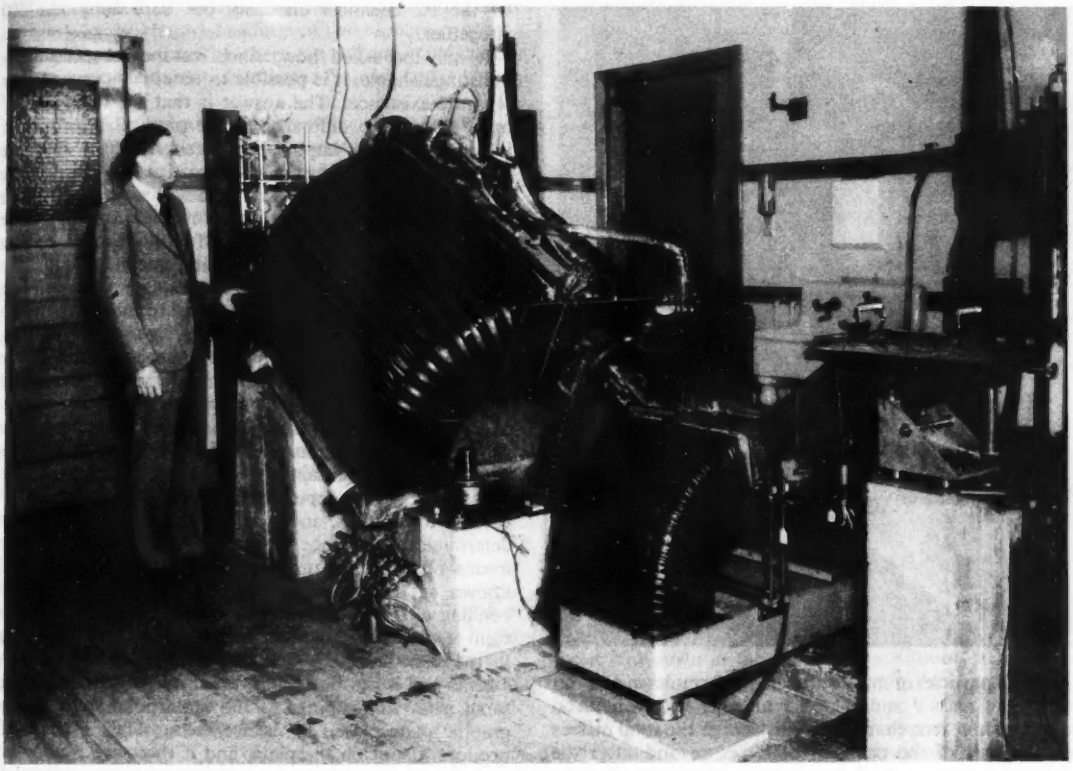
The Debate itself should be the occasion of considerable satisfaction, and it is evident that the Government welcomed the expression of opinion contained in the Amendment. We may perhaps feel that Mr. Attlee's reply for the Government was slightly lacking in vividness and made a somewhat cautious impression, but it is to be hoped that the implementation of the spirit of the House will be pushed forward zealously at the earliest opportunity.

Isotopes and the Mass Spectrograph

THE modern theory of the atom as a heavy nucleus surrounded by a number of electrons owed its origin to the experimental studies of the late Lord Rutherford, Soddy, Aston and others in the first 20 years of this century, and to the theoretical work of Niels Bohr and others. Since that time our ideas on the subject of atomic structure have been greatly refined, new types of particle have been discovered, and the laws of their behaviour have been put on a much more satisfactory foundation; but roughly speaking, the picture of an atom as a sort of solar system in miniature with a heavy nucleus corresponding to the sun, and a number of electrons moving around it in orbits, remains unchanged.

The hydrogen atom is the simplest of all, its nucleus consisting of a single positively charged particle or proton round which moves a single electron having an equal negative electrical charge and a mass about one eighteen-hundredth of that of the proton. One gramme of hydrogen gas contains roughly a million million million million atoms (i.e. the number one followed by 24 zeros, or as scientists would put it, 10^{24}) so that for convenience in discussion we can take the hydrogen atom as our unit of mass and compare all the other atoms with it. In the same way we can take the positive charge on the proton as a convenient unit of electrical charge.

Now there are known to be 92 different chemical elements ranging from the hydrogen atom of mass 1 to the uranium atom of mass 238. In practice a slight change is made and the standard taken is the mass of the oxygen atom which is called 16. On this basis hydrogen comes out with a mass of 1·0081, neon with a mass of 19·9986, aluminium with a mass of 26·9909 and so on. The fact that so many of the masses of the atoms are almost exactly multiples of the mass of the hydrogen atom was noticed over a century ago, and a scientist named Prout hazarded the hypothesis that all atoms had masses which were multiples of the mass of the hydrogen atom. However subsequent discoveries, such as for example that of chlorine which has a mass (or atomic weight, as it is called) of 35·457 units, seemed to rule out this idea. Prout's hypothesis, however, is in fact

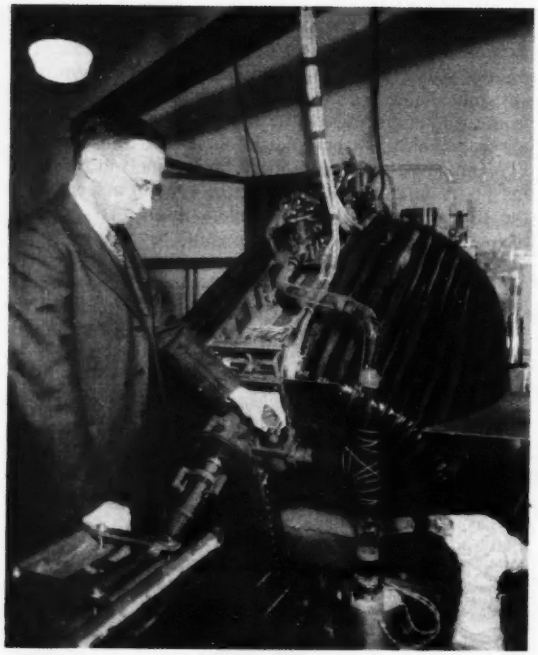


correct, for it has been found that the nuclei of atoms are in a sense compound bodies which may be thought of as being built up from a number of units each with approximately the mass of a hydrogen atom.

The present position is that it is considered that the chemical behaviour of an atom depends on the collection of electrons which surround the nucleus. This is reasonable enough, for chemical combination simply means that an atom of one kind joins up with another, the electrons of the two atoms forming, as it were, the jam that causes them to stick together. In this process of combination only the electrons are involved and the nuclei remain undisturbed. Thus for example the chlorine atom has got 17 electrons which just balance by their seventeen negative charges the seventeen positive charges of the chlorine nucleus, and if we could construct in any way an atom which normally carried with it a collection of seventeen electrons, then that atom would behave, as far as its chemical properties went, as a chlorine atom.

The phrasing of this statement suggests that it is possible to find atoms which normally have seventeen electrons which differ in some way from "ordinary" chlorine atoms, and this possibility arises because of the fact already mentioned that the nuclei of atoms are compound bodies. They may be thought of as being built up from two distinct sorts of "bricks". On the one hand there are the protons, or hydrogen nuclei having a mass of 1·0081 and a unit positive charge, and on the other a second type of particle with mass 1·0091 and no charge. The latter is known as the neutron whose existence was first suggested by Chadwick in 1932.

These bricks can be put together in various ways, and if we wished (in imagination) to build up a chlorine nucleus, that is one with seventeen positive charges, we could do it in many ways, one of which might be by the combination of seventeen protons and eighteen neutrons and another by the combination of seventeen protons and twenty neutrons. Each of these would behave chemically as chlorine because each would normally be surrounded by the seventeen electrons needed to neutralise the seventeen positive charges on the nucleus. They would be chemically indistinguishable and inseparable, but one sort of chlorine atom would have a mass 35 and the other 37. It should be noted that this way of putting the matter should not be thought of as implying that the neutrons and protons maintain their identity within the nucleus or that the chlorine atom is actually constructed by the assemblage of separate particles. We merely put the matter in this way because it is a convenient model which is useful in thinking about atoms. However, it is possible actually to mishandle atoms in some experiments with sufficient violence to disrupt some kinds of nuclei thus breaking the nuclei into portions, one of which may be a neutron or proton or the nucleus of a helium atom, while the other is a different chemical element whose nature is determined by the fact that the total charge and mass of the particles involved must remain unchanged. Thus for example a lithium nucleus of mass 6 and charge 3 interacting with a helium nucleus



(or alpha particle) of mass 4 and charge 2 results in a boron nucleus of mass 9 and charge 5 together with a neutron of mass 1 and zero charge. In this change the total masses and charges of the particles both before and after the interaction remain unchanged. Beforehand, the mass is 6 plus 4 and afterwards 9 plus 1; the charge before the interaction is 3 plus 2 and after is 5 plus zero. The interaction may be written as

$$_3Li^6 + _2He^4 \rightarrow _5B^9 + _0n^1$$

A further point is that in referring to the possible ways of putting together a chlorine nucleus we simply choose two out of many apparently possible combinations of protons and neutrons any of which would give chlorine. The two cases chosen are ones which actually occur, and the explanation as to why the others do *not* occur is a very complicated one depending on considerations of the energy involved.

The upshot of this discussion is that chemical elements may exist in a variety of forms which are chemically indistinguishable but whose atoms have different masses. These forms are known as isotopes, their existence being first suggested in connection with studies of radioactive substances by Soddy and Fajans in 1913.

The explanation of the fact that the observed atomic weights of some elements according to chemical determinations are not whole numbers is now clear. What we know as chlorine is in fact a mixture of two isotopes of masses 35 and 37 in the proportion of three to one, and boron with an atomic weight of 10·8 is a mixture of two isotopes of masses 10 and 11 in the ratio of one to four. Many other more complicated examples are known. As the result of the discovery of isotopes we must in fact recognise not 92 different sorts of atom corresponding to the 92 chemical elements but something like 300 altogether.

It may be asked how, since isotopes are chemically indistinguishable, it is possible to obtain evidence of their separate existence. The answer is that the differences of mass do make a difference to the physical behaviour of isotopes, the most important difference being a difference of behaviour of positively charged ions in magnetic fields. The term ion is used to describe an atom which has been deprived of one or more of its electrons, with the result that there is an excess of positive charge. The possession of such a positive charge means that the ion if placed in an electric field will experience an electric force setting it into motion if it is free to move. This is in fact the method used to endow positively charged particles, such as the helium nucleus or alpha particle, with the velocity necessary to enable such a moving particle to disrupt the nuclei of atoms with which it collides.

The effect of a magnetic field is rather different. If the ion is in motion the magnetic field produces a sideways force on the ion causing its trajectory to be bent. The degree of bending depends on the ratio of the charge of the ion to its mass, and it is this effect which is used to determine the presence of isotopes of different masses by means of an apparatus invented in 1919 by Aston and known as the mass spectrograph. Since the degree of bending of the trajectories of moving ions depends on the ratio of charge to mass, isotopes of different masses moving in the same magnetic field will be deviated to different extents and it can be arranged that all the particles of the same mass will impinge at the same point on a photographic plate placed to receive them. Their impact will produce a spot on the plate, and if there are isotopes of several masses present a series of spots will be produced, each corresponding to a different isotope, for which the mass can be calculated from the known constructional details of the apparatus.

The importance of a knowledge of the masses of the various isotopes which exist, and the implications of this knowledge for general atomic theory and its applications are subjects too large to be dealt with here. Suffice it to say that they are of great importance and that improved mass spectrographs are instruments of great interest to physicists.

The photographs show the mass spectrograph used by Dr. E. B. Jordan at the University of Illinois. The coils of the electromagnets used for producing the magnetic fields can be seen, and the photographic plate holder is on the right of Fig. 1 in a horizontal position. Fig. 2 shows a closer view of the apparatus including part of the pumping system which is used to maintain within the apparatus the vacuum necessary to allow the free movement of the charged ions.

Flatter than Pancakes

THE second half of the nineteenth century produced a number of remarkable English mathematicians who combined real mathematical insight with a whimsicality and humour. The most famous of them all was of course Lewis Carroll, whose literary merits have long since pushed his mathematical work into obscurity. However, his fancies had a basis of mathematical thought,

still appreciated by modern mathematicians, which may explain why the chapter headings of two modern works on astro-navigation (one of them an official publication) should consist of quotations selected from his better known works.

At the risk of seeming inappreciative of his mastery of his own special medium we may wonder how far *Alice in Wonderland* was influenced by the ideas which crystallised in the theory of the Fitzgerald contraction which was one of the forerunners of the relativity theory. We may have less doubt on this point if we read his lesser known works such as *Sylvie and Bruno* and his collected problems (which are very well worth looking at for sheer amusement) in symbolic logic. Clearly, serious thoughts were never far below the surface of Lewis Carroll's mind, and it may be that *Alice* like *Gulliver's Travels* was rather more in earnest than its modern fairy-tale status would lead us to think.

Lewis Carroll was not alone in his mixing of the serious and the amusing. The great theoretical physicist Clerk Maxwell seems to have been as ready to express himself in rhyme as in mathematical symbols; Lord Kelvin is said to have been responsible for the jingle:

> Scintillate, scintillate globule vivific,
> Fain would I fathom your nature specific,
> Poised up above in the ether capacious,
> Strongly resembling a gem carbonaceous.

Clifford, the geometer, who it is said could never work for more than a quarter of an hour at a stretch, may be suspected of at least a twinkle of humour in his statement of geometrical propositions known as Clifford's chain. They can be stated quite simply thus:

"Take three lines forming a triangle, then we can draw a circle through its vertices.

"Take four lines and omitting each in succession draw the four circum circles of the four triangles which remain. The centres of these circles lie on a line.

"Take five lines and omitting each in turn draw the five lines each of which is associated as in the previous proposition with four given lines. These five lines pass through a point."

And so on, *ad infinitum*.

However, perhaps the most remarkable of these men was Edwin A. Abbott, who published a fanciful treatise called *Flatland, A Romance of Many Dimensions* (Second Edition, 1884) which aimed at teaching geometry by means of an account of life in a two-dimensional world. The author, imagined to be an inhabitant of this world, has spent the last seven years of his life in prison as a penalty for his attempt to propagate the gospel of three dimensions revealed to him in a vision. He is a visionary creature altogether, for in the course of his life he has already in dreams had a glimpse of Lineland (a world of one dimension) and of Pointland (a world of no dimensions). Pointland is not much fun, because it is inhabited solely by one point which is unshakably confident that it, and it alone, constitutes the whole universe. Even Lineland would seem to be rather restricted, for all that its segmentary inhabitants can do is to oscillate along their line in a gay dance from time to time. Each of the participants in this limited jitterbug has two voices, a bass voice at one end and a tenor at the other, and although they can never pass each other, and never perceive each other except as the dot which a line presents when viewed end-on, they are quite happy because they can tell each other's size from the interval between the arrival of the tenor voice and the bass voice of their neighbours. The inhabitant of Flatland causes great consternation in Lineland by allowing his plane body momentarily to contain a segment of the line in which the Linelanders dwell. To them he seems to appear as if by magic and to disappear into nothingness when he moves away.

Life in Flatland itself is a good deal more complicated. All the inhabitants are flat geometrical figures, straight lines being women, sharp-pointed isosceles triangles being ignorant stupid creatures whose dullness is the greater the sharper the angle of their vertex. The middle class consists of equilateral triangles, the professional men are Squares and Pentagons (the author is a Square) and nobility sets in at the Hexagons, and increases until the figure has so many sides that it is ranked as a Circle, or a member of the priestly class. To us, three dimensional Spacelanders, it is easy to distinguish between these figures, but the Flatlanders are all compelled to view them edge on, and have to resort to a complicated technique in order to distinguish one from the other. Women (a depressed class in Flatland) present special difficulties, for a woman seen end on is no better than a mere dot, and special laws have been laid down in the Flatland constitution to avoid the fatal danger incurred by running into the sharp end of a woman.

We may feel sympathy with the women and wish that they could be improved in social status, but the Flatland society forbids this. We may derive consolation however, from the fact that male offspring usually have one more side than their father, so that our Square has in fact five Pentagonal sons and two grandsons who are aristocratic Hexagons. In this way a gradual ascent in the social scale is possible unless the family should be overtaken by that dread calamity "loss of sides". The worst social crime, usually visited by execution, is irregularity of figure, and the worst social upheaval which ever overtook Flatland was traceable to the foolish indulgence which permitted the survival of a seditious and iregular Circle, who evolved a cunning scheme whereby the inhabitants could paint their edges—all that the Flatlanders can see of each other—in colour schemes designed to facilitate recognition. The tide of social revolt turned when a licentious Isosceles disguised himself as a Dodecagon and wedded the orphan daughter of a noble Polygon—with disastrous results.

It is all very amusing fooling which leaves the reader with a really excellent knowledge of some parts of geometry, and even perhaps, after a perusal of the tactics adopted by the ruling Circles to maintain themselves in power in face of popular revolt, with some useful political lessons. Perhaps the transformation of a political work such as *Gulliver* into a children's tale may be compensated one day by the transformation of this lighthearted treatise on geometry into an account of and a horrid warning against the tactics of political jiggery-pokery.

Dr. Leslie H. Lampitt

For the subject of this article I have turned from the world of academic research to that of applied science. The industry to which Dr. Leslie H. Lampitt belongs is the biggest industry of them all—the food industry. Dr. Lampitt is head of the largest food laboratory in this country, a laboratory run not by the Government nor by a Research Association, but by a private firm—J. Lyons & Co. To-day it has a staff of two hundred, a large proportion of whom spend their time on fundamental research problems, while the rest are responsible for carrying on *ad hoc* research and process control. Dr. Lampitt assumed the task of creating this laboratory when he left the Army at the end of the last war, and he has directed its fortunes ever since.

It may be recalled that the first food industries to become "science-minded" were milling and brewing. For the scientist to improve the methods of production in either of these very old established industries it was first necessary to build up a structure of fundamental knowledge from which new industrial techniques could be derived, and it is very interesting to note that at the beginning of his career Lampitt had the advantage of being able to study the results and methods of early biochemical researches in both of these fields. The science of brewing he learnt at the university, and his first industrial post gave him the chance of studying the scientific problems of milling. It was in 1906, when at the age of 19 he became an undergraduate of Birmingham University, that Lampitt first came under the influence of two men who confirmed him in his love of chemistry, a subject that attracted him as soon as he was introduced to it at the Birmingham Municipal Technical School. Those two scientists—P. F. Frankland, professor of chemistry, and Professor A. J. Brown, head of the School of Brewing—were members of that band of stalwarts Joseph Chamberlain had chosen at the time Mason's College became the University of Birmingham, a band which included such names as Poynting, Hillhouse, Sonnenschein, and that of the Principal, Slr Oliver Lodge. Lampitt, who went to the university as a Priestley Scholar, graduated two years later with double firsts in Chemistry and the Chemistry of Fermentation; a year later he was awarded his M.Sc. degree. Then followed three years during which he enjoyed the inspiration of working under Brown, studying the metabolism of yeast, which formed the subject of his first paper; this appeared in the journal of the Biochemical Society, of which Lampitt is an original member.

A Versatile Undergraduate

Dr. Lampitt has always been notable for the breadth and scope of his interests, and during his time at Birmingham he was at least as active outside the laboratories as he was in them. A glutton for work, he edited the university magazine for two years; he served as secretary and president of the Guild of Undergraduates, and also acted as secretary and chairman of the Literary and Dramatic Society. He played soccer for the university's first team, and also captained the second cricket eleven. As though that was not enough, he took additional courses, in higher mathematics, accounting and bacteriology.

In 1911 he went to Brussels, as chemist to La Meunerie Bruxelloise, the largest flour mill in Belgium. The

Belgians were in the habit of turning to German universities for scientific staff, and it was something of a feather in the cap of Birmingham University and of Lampitt that he should have been chosen by such an important Belgian firm as its first research chemist. This post gave him the valuable experience of organising, from scratch, a laboratory, where, in the years 1911–1914 he initiated research into the structure of the wheat grain and the chemistry of gluten.

As soon as the Great War started he volunteered for the Army, was commissioned in the university O.T.C., and spent the next four years in uniform. November 1914 found him in France, where he was soon given a staff appointment, becoming deputy to the Military Forwarding Officer, and later M.F.O. to the B.E.F. In 1916 he was invalided back to England, where he spent many weary months in hospital until he was able, by devious means, to secure his return to the B.E.F. This time he went as a Railway Transport Officer, eventually being promoted to the post of Deputy Director of Railway Traffic. He was in charge of the Dunkerque Area during much of the time the Germans were trying to "blitz" this important British base.

Curiously enough he was not officially demobbed until August 1919 when he had already been with J. Lyons and Co. for several months!

Readers may be wondering how it was that Dr. Lampitt's chemical knowledge was not utilised during the war. That was, of course, the fate of many chemists, for the reservations that have preserved the technological basis of our war effort this time just did not exist in the Great War. The nearest the Army came to using Lampitt's chemical talents was in 1915 when he was posted to the recently-formed Gas Corps. He was one of the officers involved in planning the counter stroke to the gas attacks with which the Germans effected a sudden corrosion of the French and Canadian lines on the Western Front in April 1915.

Starts Lyons's Laboratory

It was while Lampitt was in charge of the railway services at Dunkerque that he met the late Lieut. S. M. Gluckstein, M.C., a director of Lyons, at whose invitation Lampitt joined the firm. To accomodate his embryo laboratory, the management gave him the site of a disused laundry at Brook Green, within 50 yards of the spot where the present laboratories stand. He had not only to obtain apparatus and instal his staff, but also to plan the building required to hold them. His original staff comprised two members—W. G. Messenger, who died last year, and a junior chemist, C. W. Gibbons, who is now rector of a church in the Lake District. It soon became clear that to cope with the scientific problems arising in the different branches of the firm's business would require a staff capable of tackling many and varied questions. Within a short time Dr. E. D. Hughes, a chemist with wide experience in food analysis, was added to the staff, and since then the laboratory staff has been regularly and rapidly augmented. By 1941, two hundred persons were employed there. The activities of the laboratories can be divided roughly into three: the first third concentrates on process control, the second on process investigation, and the last section on fundamental research. This horizontal division of the staff is cut across by vertical divisions corresponding to the different classes of foodstuffs—milk and milk products, flour and flour products, oils and fats, and so on—with additional divisions for the service section, and the branches of bacteriology, physics, and physical chemistry, all of which have a direct bearing on problems met with in the day-to-day running of a large catering firm.

When recruiting new personnel Dr. Lampitt looks primarily for sound knowledge of scientific fundamentals; the refinements of skill that are required when dealing with applied research problems he considers should be added to a scientist's repertoire after he has joined the staff. Dr. Lampitt believes his scientists should be given every opportunity of adding to their scientific knowledge; he encourages them to attend the meetings of scientific societies, and to visit laboratories and factories in other parts of the world. The large number of research papers published by members of his staff indicates very clearly his attitude towards publication of fundamental research results. His views on the absurd commercial secrecy that is all too frequent in Britain he has crystallised into a single sentence: "I suppose there are firms with secrets, but in my experience they are secrets chiefly in the minds of those working them".

His varied interests

Dr. Lampitt finds time for much work outside his laboratories. An original member of the Biochemical Society he has been on the committee of that body. He has also been a committee member and a vice-president of the Society of Public Analysts. He has served, with monotonous regularity, on the Council of the Royal Institute of Chemistry, of which he is now senior vice-president. He is a life governor of Reading University, and his appointment to the Council of Birmingham University makes him the first graduate of that university to serve on its governing body. He has been hon. treasurer of the Society of Chemical Industry for the last six years, and he was one of the founders of that society's very active and influential Food Group.

It is difficult to decide which of his many interests lies most near his heart, but listening to him talk of the Bureau of Chemical and Physiological Abstracts gives one the impression that he puts more store in this work than in any of his other activities. The great support he gives the Bureau, of which he is chairman, emanates from his desire to see the publication of chemical work established on a sound financial basis. Some little time ago, addressing an audience in the North, he classified scientific bodies into two groups—Professional and Publishing—and commented "Both groups are important, but I believe the second to be the more important. I frankly am more concerned with the Science than I am with the People .... I put in the forefront *continuance of publication*, and *improvement of publication*".

He has been associated with every committee formed during the last 20 years with a view to getting closer collaboration between chemical societies, and for four years he has been chairman of the Chemical Council. He has always taken a great interest in international chemical

Continued on p. 152

Cosmic Rays

MALCOLM McCAIG, Ph.D., F.Inst.P.

THE earth is continually being bombarded by a mysterious radiation which enters the atmosphere from outside. The origin of this radiation is still a subject for speculation, but by studying the processes to which it gives rise, scientists have learnt many startling facts about the structure of matter, and have obtained new evidence supporting the theories of relativity and quantum mechanics, and even suggesting fresh developments of these theories.

Radioactivity and Cosmic Rays

The possible existence of cosmic rays was first suggested by C. T. R. Wilson at the beginning of this century, as a result of experiments on the conduction of electricity through the air. Air and other gases do not conduct electricity unless they become ionised. As almost all our knowledge of cosmic rays depends on observations of ionisation, the term merits explanation.

Each atom of matter consists of a positively charged core or nucleus, around which move a number of negatively charged electrons, rather as the planets move round the sun. All electrons have the same mass and electric charge, but the nuclei of different atoms have different masses and charges; the lightest nucleus is that of the hydrogen atom and is called a proton, but even this is 1800 times heavier than an electron. In a normal atom the electric charge of the positive nucleus is just neutralised by the negative charges of the electrons moving round it. An atom which has lost an electron is left with an excess positive charge and is called a positive ion. An electron removed from an atom may remain for some time as a free electron, or may attach itself to a neutral atom forming a negative ion. A gas containing many ions is said to be ionised; such a gas conducts electricity because any object charged with electricity placed in it, attracts ions with the opposite electric charge to its own, until the charge on the ions has neutralised the charge on the object. In the earliest experiments on ionisation, the rate at which a gold leaf electroscope lost its charge was measured. Radium and other radioactive substances emit radiations which tear electrons from neutral atoms, and so produce ions. It was found that even with the most elaborate precautions, air could not be obtained completely free from ions, but it was difficult to decide whether these ions were produced solely by traces of radioactive elements, present in the air or material of the apparatus, or whether some other agency was also at work.

About 30 years ago several observers measured the ionisation of air at high altitudes by sending their apparatus up in a balloon. The ionisation was found to increase considerably at high altitudes, suggesting that some at least was produced by an agency coming from outside the atmosphere. This agency is now called cosmic rays, and its existence has been confirmed by a great variety of experiments.

Cosmic rays resemble in some respects the radiations emitted by radioactive substances. The latter radiations are mainly of three kinds: alpha rays which are positively charged nuclei of helium atoms; beta rays which are negative electrons; and gamma rays. Alpha and beta rays travel with various high velocities, but always more slowly than light. Gamma rays consist of waves, similar in nature to those of radio, light, and X-rays, but having a shorter wavelength. All these waves travel with the same velocity, and in little bundles called photons, but when the wavelength is long as with radio waves, each photon contains so little energy and is spread over such a large volume that only the wave properties of the radiation can be observed. As the wavelength is shortened, the photons have more and more energy concentrated in a smaller and smaller space, and each bundle of waves or photon begins to acquire some of the properties of a particle. Since energy and mass are known to be equivalent, it is quite understandable that photons of very short-wave radiation behave as if they possessed mass and momentum.

As cosmic rays come from outside the atmosphere, they must be capable of penetrating its whole depth, although most of them do not arrive at sea-level in the same form as that in which they entered. Gamma rays are the most penetrating form of radioactive rays, but even they cannot penetrate more than a tiny fraction of the atmosphere. Consequently it was suggested that cosmic rays were ultra-gamma rays; that is they were like gamma rays, but had shorter wavelengths and were therefore more penetrating. Actually it is now known that the cosmic rays observed at sea-level are very complex, including photons, electrons, and many new particles of a type only recently discovered. To explain how the nature of cosmic rays has been established, the apparatus used in their investigation must be described.

FIG. 1.—Cosmic Ray Telescope. Three tubular-shaped Geiger counters are placed one above the other, and record only those cosmic rays which arrive from such a direction that they pass through all three counters.

Fig. 1

FIG. 2.—Detection of Cosmic Ray Showers. Three Geiger counters are arranged in a triangular pattern, and are not set off by less than two cosmic-ray particles.

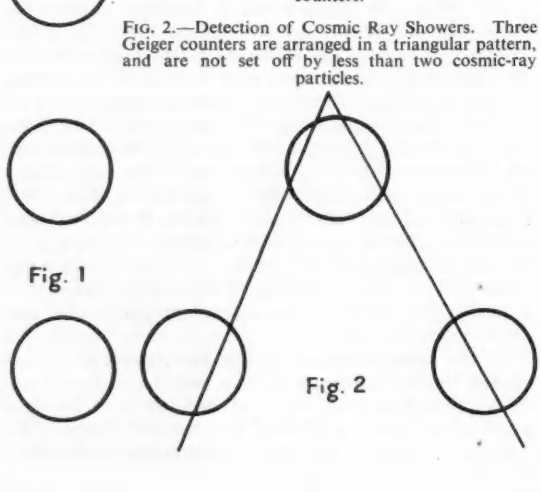


Fig. 2

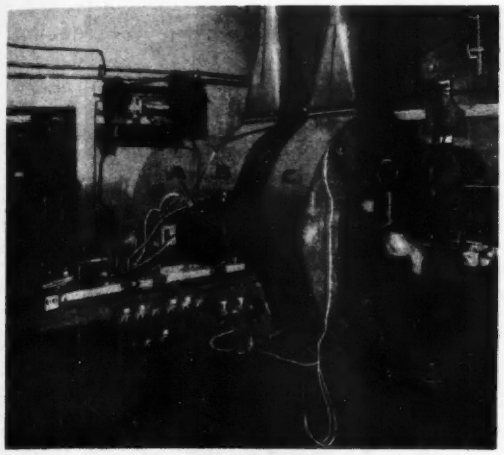


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FIG. 3.—Cloud Chamber with Large Magnet. The cloud chamber A slides along rails into position between the poles B and C of the electromagnet.

Methods of Observing Cosmic Rays

As has already been mentioned, cosmic rays are detected by the ionisation they produce. There are, however, several distinct methods of observing this ionisation.

In the ionisation chamber the total number of ions is made as high as possible by filling the chamber with a gas at a pressure of several atmospheres. In a given chamber the number of ions produced depends on the intensity of the cosmic rays. The simplest way of measuring the ionisation is to observe the rate at which a form of gold leaf electroscope is charged or discharged. The leaves are observed through a telescope and the rate at which they diverge or come together is measured. Variations in this rate indicate variations in the cosmic-ray intensity.

While the ionisation chamber gives a continuous record of the cosmic-ray intensity, the Geiger counter registers individual cosmic rays. Usually the counter is tubular in shape and contains a gas or mixture of gases at a reduced pressure. There are two electric conductors or electrodes which consist of a long thin wire and a concentric cylinder of thin metal, usually one or two inches in diameter. If a cosmic ray passes through such a counter, and produces one or more free electrons, the electrons are accelerated by the applied voltage, and by colliding with the molecules of the gas produce many ions. A sudden impulsive discharge passes between the cylinder and the wire, but is quenched after a small fraction of a second. Thus every time an ionising cosmic ray passes through the counter there is a momentary electric discharge or pulse. The pulse is amplified by a system of radio valves, and is made to operate a mechanical counting device which counts the number of pulses. Actually the type of mechanical counter used by the Post Office to record the number of telephone calls made by a subscriber is often used for this purpose. As this mechanical device makes a click every time it is operated, it is possible to hear every time a cosmic ray is recorded. If it is used in connection with a single Geiger counter of average size, from about 200 to 300 clicks per minute are heard, but they come at quite irregular intervals, just as the cosmic rays chance to pass through the Geiger counter.

A single Geiger counter is sensitive to alpha and beta particles from radioactive substances as well as to cosmic rays, and more than half the counts recorded by a single counter are due to radioactive contamination. This disadvantage can be overcome by using a system of several Geiger counters. Suppose for instance that three counters are placed one above the other as in Fig. 1. If a cosmic ray passes through all these counters, they each give a pulse at practically the same time, since cosmic rays travel very rapidly. Special valve circuits have been devised which cause the mechanical counter to register only when all the counters give pulses simultaneously. The counters are then said to be connected in coincidence. A single alpha or beta particle due to radioactivity cannot penetrate far enough to discharge two counters, and is not recorded by a coincidence set. Of course separate particles may by chance enter each counter at the same time, but the probability of this happening is small. An arrangement of counters such as that in Fig. 1 acts as a kind of telescope for cosmic rays, since it records the number of rays travelling in a given direction.

Suppose three counters are arranged in a triangular pattern as shown in Fig. 2. The system cannot be set off by less than two simultaneous particles. As such a system does register a considerable number of counts, it is concluded that cosmic rays frequently arrive in groups or showers as they are customarily called. In some of the more complicated investigations of cosmic rays 100 or more counters have been used in one counting system.

The cloud chamber was invented by C. T. R. Wilson, and was originally used to investigate the alpha and beta particles of radioactive substances. It has proved one of the most fruitful methods of investigating cosmic rays. The cloud chamber depends on the principle that if air is supersaturated with the vapour of water or some other liquid,

FIG. 4. — Small Cosmic-Ray Shower including Positive Electrons. The paths of the particles curve in both directions, indicating that both positive and negative electrons are present. Some particles are absorbed in the horizontal lead block which crosses the middle of the chamber, but other particles are produced in the block by the cascade process described in the text.

drops of the liquid will form preferentially around any ions that may be present. A charged particle which passes through a gas leaves a trail of ions, and the droplets condensing around these ions form a thin trail of mist which indicates the path of the particle. A powerful light enables a photograph of such a track to be made.

To produce the required degree of supersaturation, the gas in the cloud chamber is cooled by allowing it to expand suddenly. If the expansions were made at random, only a few of them would chance to coincide with the passage of cosmic rays, and the chance of obtaining evidence of any of the more rare cosmic-ray phenomena would be exceedingly small. The waste of time and photographic material involved in such a procedure would be enormous. The difficulty is overcome by operating the cloud chamber in conjunction with a set of Geiger counters, which operate the chamber when a cosmic ray passes through them. The idea can be improved so that the chamber is operated only when some special kind of cosmic-ray phenomenon such as a shower occurs. A counter-controlled chamber involves an intricate set of electrical gadgets. It may remain quiet and in darkness for several hours. An observer might think it was not working. Suddenly there is a loud report as the expansion is made, a bright flash of light as the photograph is taken, a hum of electric motors as the chamber and camera are reset, and after a few minutes the chamber is ready again.

The appearance of a cloud chamber track sometimes enables the observer to decide whether it was due to a proton, electron, or some other type of particle. Further information about the particle and its energy can be obtained by placing the chamber in a strong magnetic field. Fig. 3 shows a picture of Blackett's cloud chamber with a large electromagnet to produce such a field. In a magnetic field the particles follow curved tracks, the curvature depending on the mass, charge, and energy of the particles. With particles of high energy, no appreciable curvature can be produced, and the tracks due to different types of particle are very similar. In these circumstances it is difficult at present to deduce reliable information about the more energetic cosmic rays.

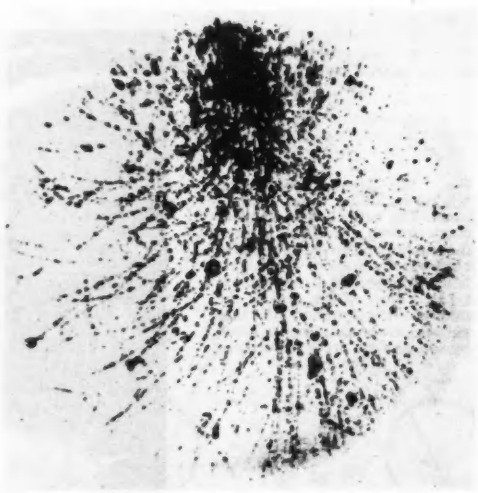

FIG. 5.—Large Cosmic-Ray Shower. This shower contains many particles of both signs. The photograph is a negative, showing the tracks in black on a white background.

FIG. 6.—Production of an Electron Pair. In the lower half of the photograph a pair of electrons of opposite signs are produced by a photon which leaves no track.

The Discovery of New Particles

One of the earliest triumphs of the cloud chamber technique as applied to cosmic rays was to show that they contained positive as well as negative electrons. The positive electron,—or positron as it is frequently called—has the same mass and magnitude of charge as the ordinary electron, but its charge has the opposite sign. It was discovered independently by Anderson in America and Blackett in England in 1932, when tracks similar to those produced by electrons, except that they curved the opposite way in a magnetic field, were observed. Such tracks can be clearly seen in Fig. 4, which is a photograph of a small shower, and in the large shower photographed in Fig. 5 there are many tracks of both negative and positive electrons. Since the positron was first discovered in cosmic rays, artificially radioactive substances which emit positrons have been prepared in the laboratory.

More recently still an entirely new type of particle has been discovered in cosmic rays. This particle has a mass intermediate between that of a proton and an electron. The exact value is a little doubtful, but it appears to be 200 to 300 times that of an electron. The charge of this particle may be either positive or negative, and is believed to have the same magnitude as that of an electron. Various names such as "barytron", "mesotron", and "meson" have been suggested for this particle, but in the remainder of this article the name meson will be used. The meson has not yet been produced in the laboratory without the aid of cosmic rays.

Influences on Cosmic Rays

Besides giving information about the types of particle present in cosmic rays, the cloud chamber shows how rays of one kind react with matter to form other kinds of rays. Thus Fig. 6 shows an electron and a positron produced by some kind of non-ionising radiation which does not produce a track. Most probably this was a photon.

The history of how the nature of cosmic rays has been established and the processes by which they react with matter elucidated, is too long to give in detail. It is a history of painstaking experiment and careful thought, often involving complicated mathematical calculations. Many setbacks have been encountered, and many false assumptions have had to be abandoned. The description of cosmic-ray processes which is considered most probable to-day differs enormously from that which would have been given only five or six years ago. Although it is almost certain that some of the views held to-day will require modification in the future, it does appear possible to give a reasonably accurate description of what happens to cosmic rays as they approach the earth and traverse its atmosphere.

Leaving for the moment the unsolved problem of the origin of cosmic rays, it has been estimated that about 20 charged particles cross one square centimetre of space from one side per minute. Long before these particles enter the earth's atmosphere, they come under the influence of the magnetic field of the earth. Particles which approach one of the magnetic poles vertically are not deflected by the magnetic field, and all the particles approaching the polar regions are able to reach the atmosphere, but those approaching the equatorial regions follow curved tracks, as shown in Fig. 7. The less the energy of the particles, the more curved are their paths; and particles with less than a certain minimum energy follow such curved paths that they cannot reach the earth in the equatorial region. Consequently the intensity of cosmic rays is greater in the polar than in the equatorial regions, incidentally showing that the primary radiation does consist of charged particles and not photons, as was at one time supposed. Referring again to Fig. 7 it can be seen that a positively charged particle cannot approach at a very oblique angle from the east. Conversely a negatively charged particle cannot approach at an oblique angle from the west. Observations at ground level near the equator show an excess of particles approaching from the west, and this suggests that the primary cosmic rays are positively charged, and at the moment the most satisfactory theory is that they are protons. Some scientists believe that positive and negative electrons and even photons accompany these protons, but are absorbed in the upper atmosphere.

Assuming that the more penetrating cosmic rays are due to protons, most of the more important cosmic-ray phenomena can be explained. The protons do not penetrate very far themselves, for having very high energies they react with any atomic nucleus they happen to approach. Usually the result of this reaction is the production of mesons, which are ejected in approximately the same direction as that in which the proton was originally travelling. These mesons have a greater penetrating power than either protons or electrons, and it is mainly

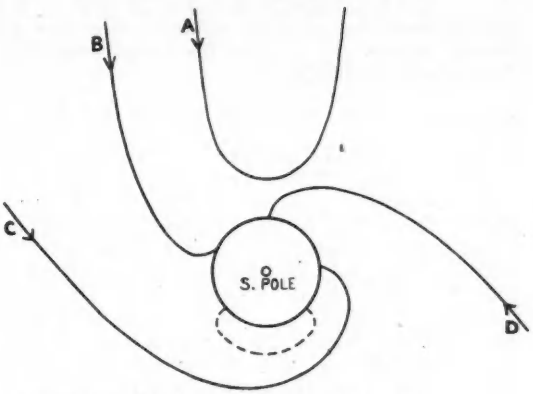

FIG. 7.—Paths of Positively Charged Particles in the Earth's Magnetic Field. All the particles are assumed to move in the plane of the equator. A has too little energy to reach the earth. B, C, and D have a greater energy. Note that B approaches the earth at a low angle from the west, but it is not possible for a particle of this energy to approach at a low angle from the east, since it would have had to start from a point on the earth's surface as shown by the broken line. Negatively charged particles would follow paths curved in the opposite direction, and could not approach at a low angle from the west.

mesons which reach the earth and even penetrate to some considerable depth into the earth's crust.

The ultimate fate of the meson is usually a spontaneous disintegration which occurs on the average two or three millionths of a second after the meson was produced. When a meson disintegrates a high-energy electron is produced. Most of the electrons observed at ground level are due to the disintegration of mesons. Many of these electrons have sufficient energy to promote further reactions. Thus if an electron is slowed down by approaching an atomic nucleus, some of its energy is radiated as a photon. The process resembles the production of X-rays, but the energy of the photon is much greater than that of any produced in an X-ray tube. A photon whose energy is more than equivalent to the mass of two electrons can produce a pair of electrons, one with a positive and the other with a negative charge. Any surplus energy in excess of that required to produce the mass of the electrons is used to supply them with kinetic energy. This process has already been illustrated in Fig. 6. If the electrons have sufficient energy they may produce more photons, and the process may be repeated many times, until a large shower such as that photographed in Fig. 5 is produced. This cascade process may continue until a shower containing more than a million positive and negative electrons and photons is produced, but ultimately the energy of each particle becomes so small that the process ceases and the shower is absorbed. In a dense material such as lead very concentrated showers are produced in a very small space, but in air the photons and electrons travel greater distances between each transformation, and the resulting shower is less concentrated, and may extend over a wide area. Although most large showers of the type just described would be absorbed by five inches of lead or less, fresh showers are produced by mesons under the greatest thicknesses of matter yet investigated. In this account only the more common processes observed in cosmic rays have

been discussed, but it should suffice to show how the primary protons can produce the complicated effects observed at ground level.

Applications

The strictly practical application of cosmic rays may never be very great. There is a possibility that fluctuations in cosmic-ray intensity may yield information of value in weather forecasting. It has also been suggested that cosmic rays are responsible for a small proportion of the mutations which make the offspring of animals and plants differ from their parents. These mutations have made evolution possible, and are essential for the work of the animal and plant breeder. As yet there is no evidence that the mutations produced by cosmic rays are either because of their nature or number particularly important.

The real justification for cosmic-ray research lies in the great progress it has made possible in our knowledge of physical laws and natural processes. In his attempts to explain cosmic ray phenomena, the theoretical physicist inevitably uses the new theories of relativity and quantum mechanics. In so far as he is successful the value of these theories is vindicated. It is not possible to explain many of the ways in which these highly mathematical theories have been applied in the study of cosmic rays, but one simple and striking example can be quoted.

A well-known result of the theory of relativity is that a clock moving bodily relative to an observer would appear to lose, although another observer moving with the same velocity as the clock would find that it kept the correct time. No ordinary clock can be made to travel with a sufficiently great velocity to test this prediction, but the meson can be used as a kind of natural clock. The meson disintegrates spontaneously after an average time of a few millionths of a second *measured by a clock at rest with respect to the meson*. This time appears longer when measured by an observer with respect to whom the meson is travelling at a high velocity. Apart from the theory of relativity a meson travelling with say nine-tenths of the velocity of light would on the average travel nine times as far before disintegrating as one travelling with one-tenth of the velocity of light. But according to the theory of relativity, a clock travelling with nine-tenths of the velocity of light would appear to lose rather more than one second in two. This means that if a meson disintegrates after an interval of say one-millionth of a second measured by its own time, the interval measured by an observer relative to whom the meson is moving will appear to exceed two-millionths of a second. On the other hand the relativistic variation of time makes very little difference for a velocity one-tenth that of light. Consequently the faster meson can travel not nine times as far as the slower one before disintegrating, but approximately twenty times as far. Experiments confirm that the distances travelled by fast mesons before they disintegrate is more than proportional to their velocity, in conformity with the theory of relativity.

Another extraordinary fact is that before the meson was discovered experimentally, a Japanese named Yukawa assumed the existence of a particle of very similar properties. At the time he was elaborating a theory of atomic nuclei. An insight into the nature and structure of atomic nuclei, and the circumstances which govern the transformations of the nuclei of one element into those of another, may prove to be the most important result of cosmic-ray research. Ever since Rutherford first succeeded in disintegrating an atom, scientists have speculated on the possibility of harnessing the enormous energy of the atomic nucleus. Any research which sheds light on the laws which govern nuclear processes may bring this end nearer to attainment.

Future Research

As soon as the end of the war permits, many scientists will wish to resume cosmic-ray research. By no means all the processes which occur as cosmic rays pass through the atmosphere are known, and the maximum energy of cosmic-ray particles is a particularly perplexing problem. Perhaps the most tantalising problem of all is that of the origin of cosmic rays. At one time it was supposed that cosmic rays were produced either by the building up or breaking down of matter. Although Millikan still upholds this view, other scientists have pointed out that it involves many difficulties, and is completely incapable in its present form of accounting for the more energetic cosmic rays, since they would require the disintegration in one process of a mass greater than that of a uranium atom, the heaviest atom known. Some years ago the Scandinavian worker Alfvén proposed an alternative explanation. He pointed out that in the laboratory the method of obtaining high energy particles is to use a cyclotron. In this apparatus charged particles are accelerated time after time by an electric field, as they go round and round in a spiral path under the influence of a magnetic field. According to him a double star may under certain circumstances act as a huge natural cyclotron. This is an attractive theory, but at present there is no direct evidence in its support.

The investigation of cosmic rays has frequently required expensive apparatus and the co-operation of a large number of research workers. In order to establish the influence of latitude on cosmic-ray intensity, A. H. Compton organised an investigation involving observations at 69 different stations on the earth's surface. Obviously work on such a scale requires careful planning. This imperative need for planning in order to carry on research in a branch of pure science is important, since it has been argued that it is impossible to plan research in pure science.

[The author wishes to thank Professor P. M. S. Blackett for permission to include Figs. 3, 4, 5 and 6.]

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Ozone in the Air we Breathe

[CONCLUSION]

J. L. EDGAR, B.Sc., Ph.D.

In the first part of this article, which appeared in the April number, the meteorological importance of the ozone present in the atmosphere and the difficulties involved in its accurate determination were discussed; the physical photo-electric cell method of measuring atmospheric ozone contents was described; and the problems to be overcome for successful chemical determinations were considered.

It has already been stated that ozone condenses to a dark blue liquid which boils at −112°C.; if, therefore, air which contains some ozone were to be cooled to a temperature below −112°C. the ozone should condense into its liquid form in exactly the same way as gaseous water, or steam, condenses into the liquid form when the temperature of an air-steam mixture is allowed to drop below 100°C. Now liquid oxygen boils at −183°C. or 71°C. lower than does liquid ozone, so that if a mixture of air and ozone is cooled by means of liquid oxygen, the ozone should condense into the liquid form. In a long series of experiments this has actually been shown to be the case, and by passing artificially prepared mixtures of ozone and oxygen through special vessels cooled in liquid oxygen some of the ozone has been found to condense out; when the vessels are removed from the cooling baths the ozone boils, and the concentration of ozone in the resulting air-ozone mixture is therefore greatly increased.

This method seems to be so simple and straightforward that it would appear to be too good to be true; and in actual fact it is. The big snag is the vapour pressure of the liquid ozone.

Even at the temperature of liquid oxygen, it has quite an appreciable vapour pressure and its molecules are constantly trying to leave the liquid surface; further, since in the method of condensation a large quantity of air will be drawn over the liquid surface, this tendency to evaporate will be accentuated just as the rate of evaporation of alcohol from a dish is increased when a current of air is blown over it. It was therefore obvious that merely passing air through a cooled vessel, although it might conceivably condense *part* of any ozone present, would most certainly not condense 100% of the gas; a method was therefore required whereby the ozone would not only be condensed but would also be absorbed on an active surface, i.e. could be retained for further examination.

The two things required of such an adsorbing medium were that it should have a large active surface, and that it should be absolutely chemically pure; any trace of impurity that could be oxidised would certainly destroy the very small quantities of ozone that were sought.

After many substances had been tried, an ideal medium for the absorption of ozone was found to be silica gel; it was found that all forms of the industrial gel contained some impurities and, although they were highly efficient for the adsorption of ozone, some of the gas was destroyed. The material had therefore to be made in the laboratory under perfect chemically clean conditions and it was found that the gel thus prepared would, when cooled in liquid oxygen, condense and adsorb completely any ozone that was present in a mixture. The concentration of ozone in experimental ozone-air mixtures was varied from one part per million to one part per hundred million (the reported concentration of ozone in air) and it was found that when these mixtures were passed at a rate of about four litres per minute through specially designed traps packed with silica gel and cooled in liquid oxygen, the whole of the ozone was removed from the mixture, the gas after passing through the trap being ozone-free; when the experiments were concluded, the cooling bath was removed, and the ozone was allowed to evaporate. This was passed through a solution of potassium iodide and was determined chemically by the standard method. The actual amount of ozone that had been put into the ozone-air mixture was measured in a special apparatus, and it was found that the whole of this ozone was recovered, thus showing that none of it was destroyed during the adsorption and condensation process; here, therefore, was an ideal method for increasing the concentration of the ozone to such an extent that a reliable chemical determination would be possible.

Separation of Ozone from Other Gases

The other problem to be solved was the separation of the condensed ozone from any other oxidising gases that might be present in the atmosphere.

The principle employed is exactly the same as that employed in the preparation of pure liquids by distillation; when a liquid is to be purified by distillation heat is put into it until it boils, the pure vapour distills off, and the impurities—solids or liquids with higher boiling points—are left behind. When ordinary tap water is to be purified it is brought to its boiling point and the vapour is condensed to give pure (distilled) water, the solid impurities being left behind as a residue; we all know of the residues left behind in the kitchen kettle.

To see how this principle is applied we consider an actual experimental determination of the ozone content of an air sample. The air is first drawn through a cotton wool filter in order to remove any dust particles and then, before it goes to the cooled trap, through an absorption tower packed with anhydrous calcium chloride, a chemical which very readily absorbs water and thus removes the water vapour from the air; if this precaution were not carried out the cooling trap would very soon become completely choked with ice. From the absorption tower it is drawn through a manometer which is used to measure the quantity of air that is treated, and then through the cooling trap which is packed with the pure silica gel and which is immersed in liquid oxygen; sufficient air is drawn through the apparatus, (shown diagrammatically in Fig. 5, K being the cotton wool filter, D the absorption tower, C the manometer, and A the cooling trap immersed in liquid oxygen) to give a measurable quantity of ozone and the experiment is then discontinued. The trap in its cooling bath is detached from the rest of the apparatus.

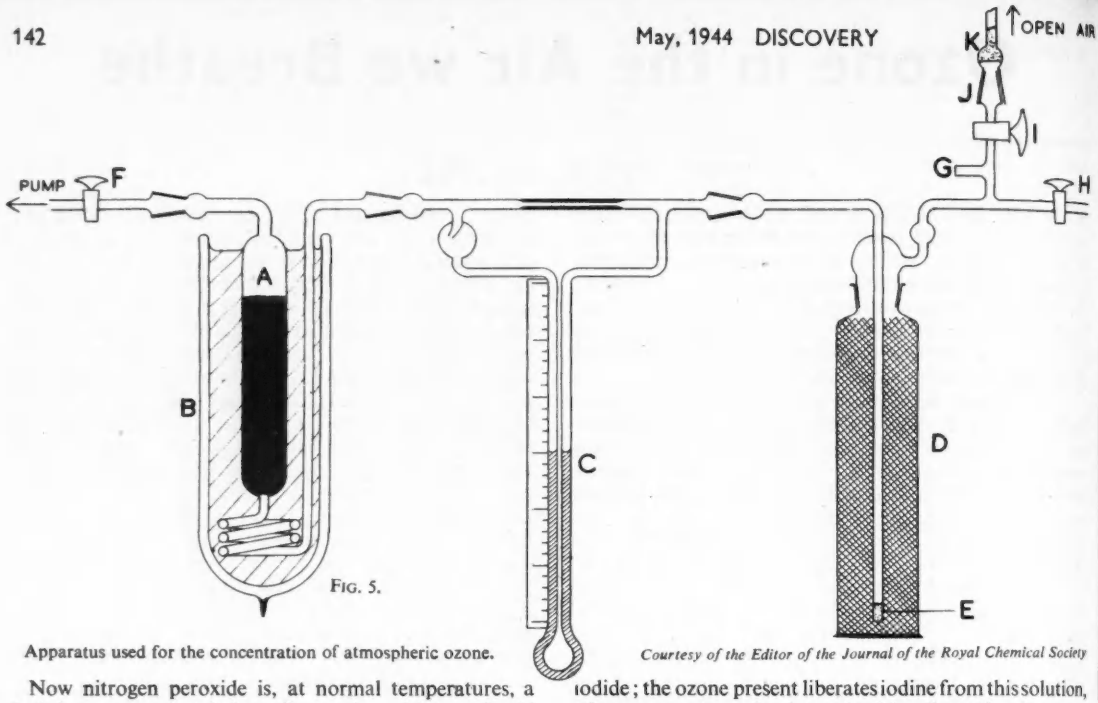


FIG. 5.

Apparatus used for the concentration of atmospheric ozone.

Courtesy of the Editor of the Journal of the Royal Chemical Society

Now nitrogen peroxide is, at normal temperatures, a dark brown gas, but it is easily condensed into a liquid since its boiling point is 22°C. and on further cooling it freezes to give a yellowish crystalline solid whose melting point is −10°C.; thus, on entering the cooling vessel which is at −180°C. any nitrogen peroxide present is immediately frozen out in the solid form, together with any ozone that may be present. If any carbon dioxide is present it will also remain in the trap for at low temperature this gas forms a white solid subliming, i.e. passing direct from the solid to the gaseous state, at −78°C.

Thus, in the trap there is now a mixture of liquid ozone B.P.−112°C.), nitrogen peroxide (M.P.−10°C.), carbon dioxide (S.P. −78°C.), and any other oxidising gases which may be present and which would most certainly be solid at this low temperature; we have, therefore, a position exactly analogous to the case of tap water, i.e. we have ozone present in the liquid form contaminated by solid impurities, and it should therefore be possible to purify the ozone, or in other words to separate it from the solid impurities, by the same method of boiling off the pure substance or, to use the correct technical term, by applying the principle of fractional distillation.

It has been shown experimentally that it is actually possible to separate ozone from other gases by applying this method; the cooling trap is removed from the liquid oxygen bath, held in a bath at a temperature of −120°C. (the cooling mixture is alcohol and solid carbon dioxide super-cooled with liquid oxygen), and a slow current of pure dry oxygen is passed through the trap. At this temperature, which is very near the boiling point of the liquid ozone, the whole of the ozone is evaporated off and there is left behind the solid nitrogen peroxide together with the carbon-dioxide which is inert and would not affect the experimental results even if a little of the gas did come over. The issuing gas mixture passes through an absorption pipette which contains a standard solution of potassium iodide; the ozone present liberates iodine from this solution, whose amount can be determined by direct titration.

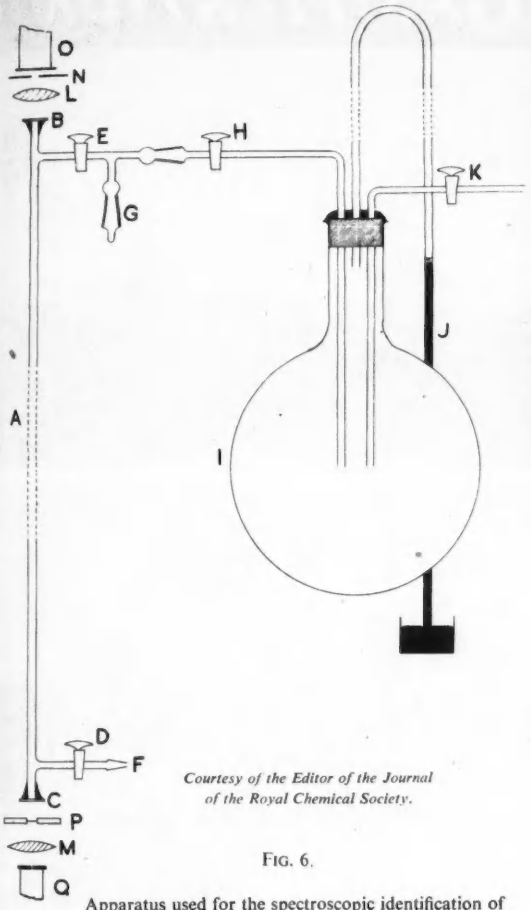
When all of the ozone has been removed from the cooling trap there is left behind in it the nitrogen peroxide which can then be determined separately; thus nitrogen peroxide and ozone determinations are carried out on the same sample of air. It has been shown that the amounts of each present in London air are approximately one volume of ozone and one of nitrogen peroxide in one hundred million volumes of air.

Spectroscopic Identification

In the course of this work it was shown beyond any doubt that there is present in the atmosphere a small but appreciable amount of ozone; that the oxidising gas which was being determined was actually ozone was confirmed by several chemical methods, but a most important confirmation was obtained by resorting to an adaptation of the original spectroscopic method of the physicists.

The process finally worked out to achieve this end was as simple as it was effective; in the normal routine method of determining ozone the gas is absorbed in the potassium iodide solution, as described above. In order to isolate it for its spectroscopic identification it is fed not into potassium iodide but into a micro-absorption trap attached to the main trap, packed with silica gel and cooled in liquid oxygen. Thus, as the main trap is heated up and the ozone distills off it is once again condensed in the small trap, being obtained in the pure state.

The micro-trap containing the re-condensed ozone, still in its bath of liquid oxygen, is then transferred to the apparatus shown in Fig. 6 in which its absorption spectrum may be determined. This piece of apparatus, which was specially designed for the job, actually consists of two parts separated by the tap H. The part on the left-hand side is used for photographing the ozone and consists of a



Courtesy of the Editor of the Journal of the Royal Chemical Society.

FIG. 6.

Apparatus used for the spectroscopic identification of atmospheric ozone.

straight glass optical tube A, about a hundred centimetres in length, sealed at each end by quartz windows B and C which allow the passage of ultra-violet light. At one end of this tube there is a strong source of ultra-violet light and a quartz lens system N L, while at the other is a second quartz lens system P M and a quartz spectroscope Q; the tube may be evacuated through the tap D, and known quantities of ozone may be admitted to it through the tap E from the calibration apparatus on the right-hand side of H.

The results of a typical experiment are shown in Fig. 7. The tube A is first filled with pure oxygen and the spectrum is photographed; this serves as a blank control experiment, and the spectrum is No. 1 on the photograph. The tube is then evacuated by means of a high vacuum pump through the tap D, which is then closed, the taps E and H also being closed, and the micro-absorption trap, still in its cooling bath, is then attached to the apparatus at F, a small tap on the trap being closed; D is then opened, the cooling bath is removed, and the ozone in it thus boils off and passes into the optical tube. The tap on the absorption trap is then opened slowly and its contents are then thoroughly washed into the tube by means of a slow current of air; the spectrum is then photographed and this is No. 2

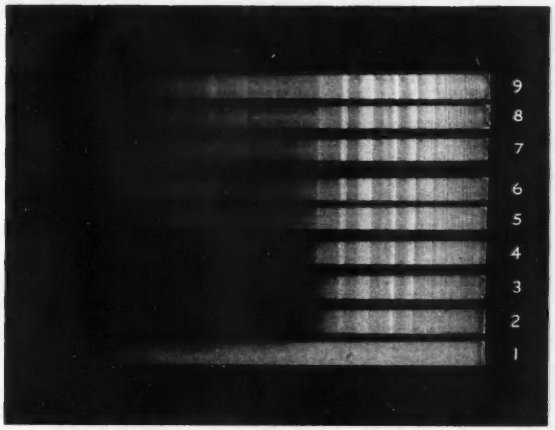


FIG. 7.—The absorption bands due to ozone are the dark gaps on the left which are pronounced in Nos. 3 and 4 where the zone concentration is comparatively high and disappear almost completely at No. 9, corresponding to a very small concentration. The bright lines on the spectra are due merely to the source of ultra-violet light used.

on the plate. An absorption pipette containing standard potassium iodide solution is then attached to the apparatus at G and the contents of the optical tube are blown through this pipette by means of a current of oxygen; the ozone is thus absorbed, and the amount of iodine liberated is determined titometrically so that the actual amount of ozone whose spectrum has been photographed is determined chemically. The volume of air from which the ozone has been extracted is measured by means of the calibrated manometer on the concentration apparatus, thus giving the actual concentration of ozone in the atmosphere.

The apparatus is now calibrated, by repeating the same process with oxygen-ozone mixtures of known composition. These form spectra Nos. 3—9, and correspond to decreasing proportions of ozone. By comparing No. 2 with these an estimate of the ozone content in the actual sample can easily be obtained. The very strong absorption bands both from ozone condensed from the atmosphere and that prepared in the laboratory will be noted, and these photographs provided the last piece of evidence of the presence of measurable quantities of ozone in the air we breathe.

By this method the concentration of the ozone is increased 28,000 fold, and the amount of ozone condensed and measured in the optical tube whose length is 111 centimetres is equivalent to a column of air 31 kilometres in length. It was stated before that the photographing of an ultra-violet light source at a distance of four kilometres from the spectroscope presented major experimental difficulties; to do it at a distance of 31 kilometres by ordinary means would have been quite impossible.

The whole apparatus has been designed so that it is portable, and determinations have not only been carried out in London in the neighbourhood of Hyde Park, but

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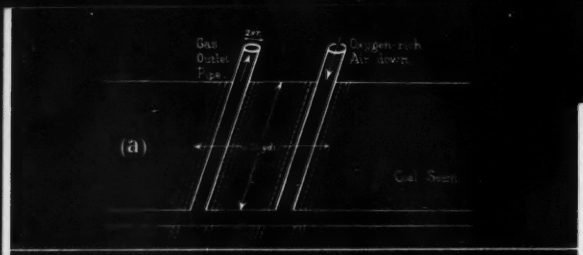
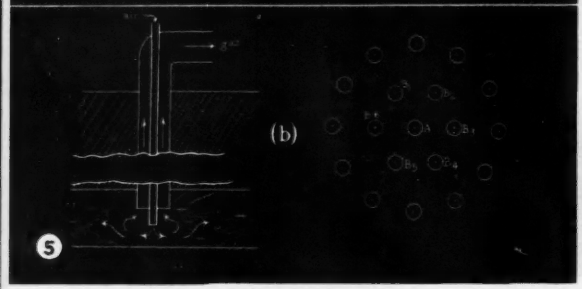
GASIFICATION OF C





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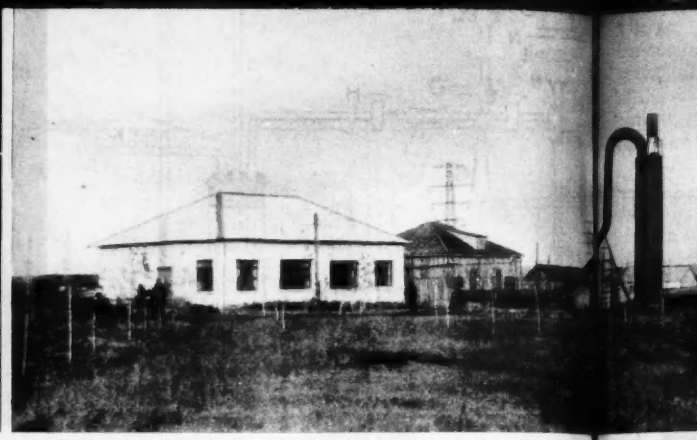

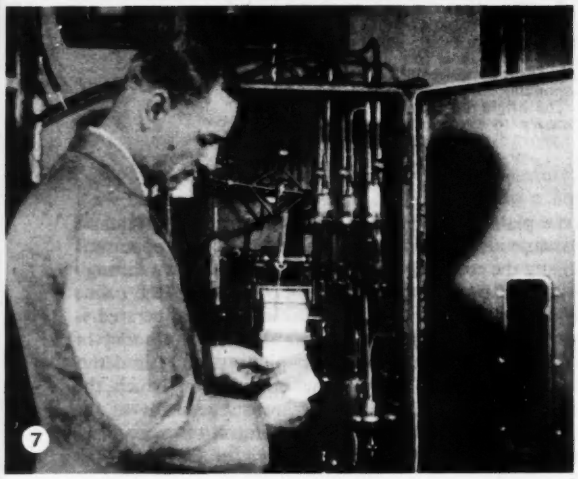

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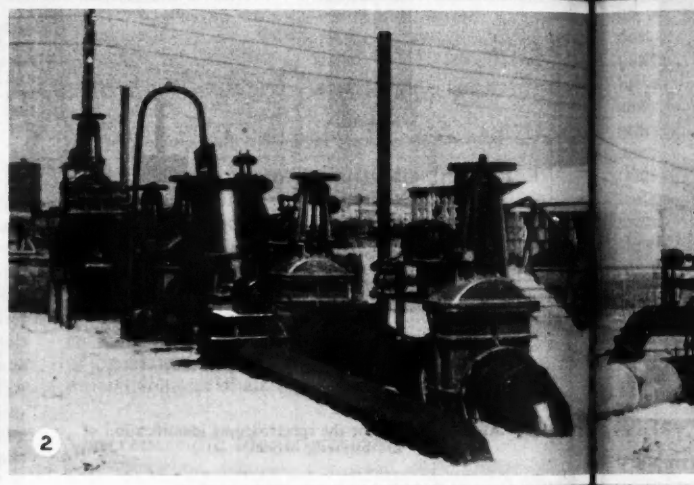

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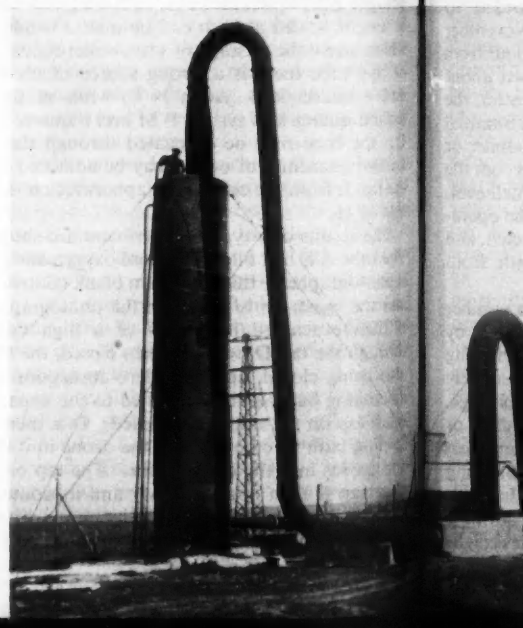


MR. F. G. KENT'S article on the Underground Gasification of Coal in the March number elicited such interest that we have endeavoured to supplement it pictorially with the above pictures and diagrams.

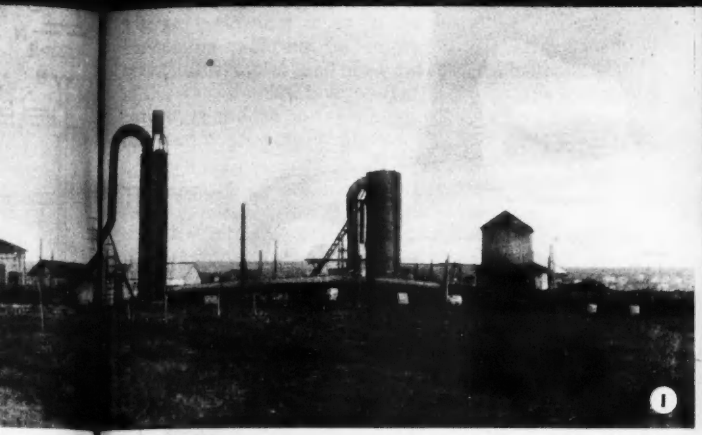
1. This panorama shows the *podzemgaz* (underground gas) shaft in the Shakhty District of the Donbas, Azov-Black Sea Territory. Preliminary experiments there were successful, and gas production on an industrial scale was started in 1936. The first coal seams were set afire, and the gas led away to provide power for the electric power station situated 1½ kilometres away. It should be stressed that the Russian experiments were made with a view to utilising coal seams of such low quality that they would be uneconomic to work by ordinary methods. Exploitation by underground gasification has been restricted to this kind of seam.

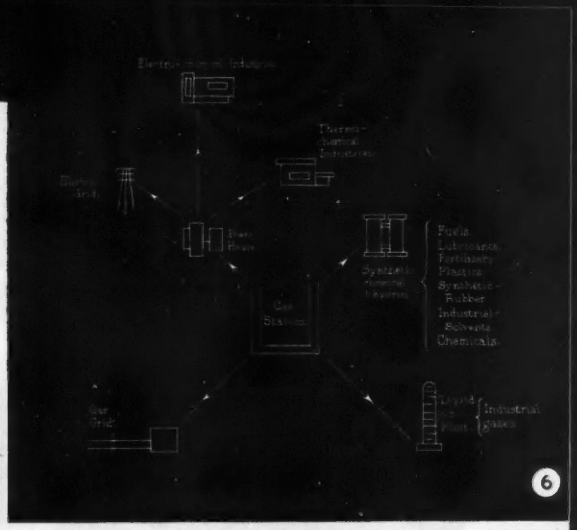
2 and 3. There are three main methods of underground gasification designed to meet the different dips of coal seams. The *stream flow method* is suited to steeply inclined seams; for horizontal streams the *filtration method* is used, while the *bore hole and drilling method*, a combination of the other two techniques, is considered most satisfactory for gently sloping seams. Most successful and firmly established of the three is the stream flow method, as used at Gorlovka in the Donbas.

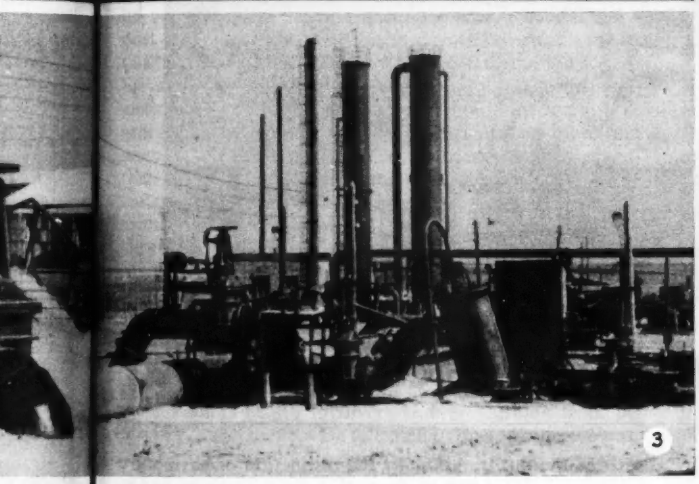
4. One of the first plants started by the Podzemgas Trust. A gas purifier, or scrubber, and gas pipes stand ready to receive the gas that will come up the shaft on the left.

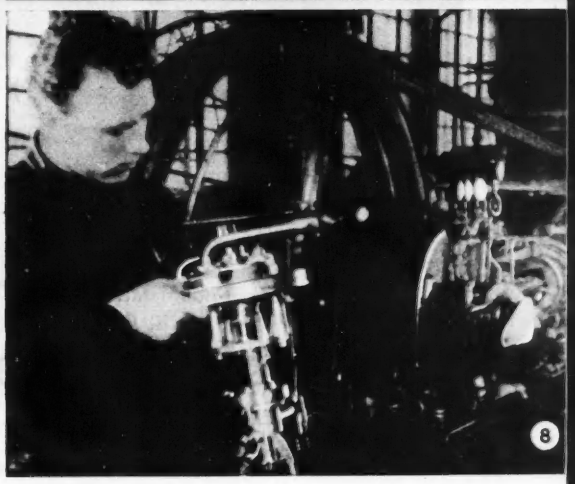
5. Diagrams showing the operation of the flow and the filtration methods. Diagram *A* shows two shafts, 200 to 300 yards apart, driven down through the nearly vertical seams, and connected by a horizontal gallery. The coal is ignited and combustion maintained by blowing compressed air down one shaft, the gas being brought up to the surface by the second shaft. In this way the fire burns progressively upwards along the seam to the surface. The photograph shows the 3-feet gas main (centre) entering the ground at an angle corresponding to the dip of the coal seam. The main control valves can be seen. Diagram *B*, shows, on the right, the bore holes arranged in concentric rings. The holes

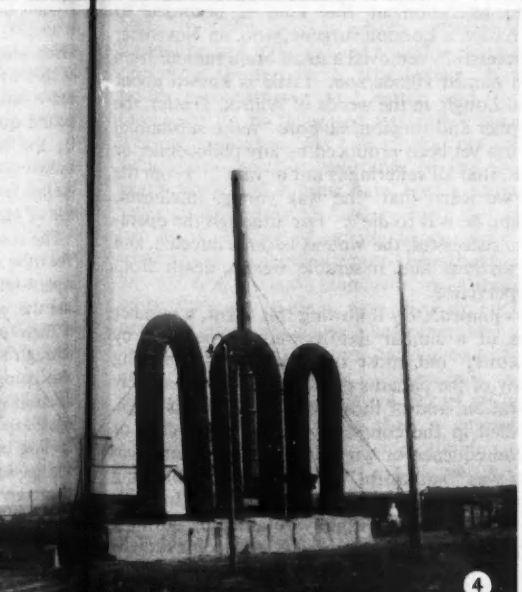
ON OF COAL SEAMS











are 20 to 40 yards apart. The other figure shows how the initial burning of the coal is promoted; air passes down the central pipe, gas is brought up in the annular space between this pipe and the main shaft; "galleries" to connect hole A with holes B_1—B_6 are produced by burning the coal at the bottom of all seven bore holes; the cavities so burnt out enlarge until eventually they connect up with each other. The next stage (the centre pipe having been removed from each shaft) is to pump air down the central bore hole; the gas is withdrawn from the bore holes of the first ring. Burning also proceeds along cracks in the seam, and this leads to the interconnection of the primary cigar-shaped zones—the radii AB_1, AB_2, and so on—so that little coal remains by the time gasification of the first section of the coal field is stopped. The next section is exploited by pumping air *down* the first ring of borings and tapping the gas from the second. So the field is explored, ring by ring.

6. A flow sheet indicating how underground gasification can supply the needs of different industries. The gas is not only a source of power but of valuable chemicals. One important invention associated with the process is the gas turbine for generating electricity developed at the Kharkov Mechanical Engineering Institute.

7. An underground gasification plant is *not* a gas-works built underground. The men who work the process do so from the surface. Here is one reading a continuous gas recorder that gives analyses of the mixed gases issuing from the coal seam burning away underground.

8. Air enriched in oxygen is a pre-requisite of underground gasification. Liquefaction of air provides it. A worker holds a turbodetander designed by Professor Peter Kapitsa, Director of the Institute of Physical Problems. Expanding air is forced to drive a turbine; this provides a means of cooling the air considerably, enabling it to be liquefied by only 5 atmospheres of pressure, as against 200 atmospheres with the Linde process. Liquid air is produced from the turbodetander within about 20 minutes of starting. 29 to 30 kilograms of liquid air are produced by it each hour with an energy consumption of only 1.7 kWh. per kilogram. (The best description of this machine available appeared in *Voks Bulletin*, Nov. to Dec., 1940).

Surgery of the Brain in Peace and War

THE dramatic progress of surgery during the last half-century has been characterised, among other things, by an interesting tendency on the part of the bolder spirits among surgeons to move from the lower regions of the body upwards. This tendency, of course, parallels the advances of antisepsis and asepsis since the introduction of these methods by Sir Joseph Lister. Operations on the pelvic organs, around which the body's defences against bacteria are particularly good, first became possible; then major abdominal operations; later the interior of the chest was attacked; and still more recently the brain has become a practicable field for suitably skilled surgeons. At the present day, brain surgery is a particularly exciting subject: it has passed the stage where pioneers are groping in the dark, but shows no signs of passing into a phase of stereotyped procedures; moreover, every fresh advance gives us further insight into the working of that most remarkable of all living structures, the human brain.

Although for many centuries, medical men had occasionally felt disposed to bore holes in patients' skulls for dubious reasons and with still more dubious results, modern brain surgery really started with the operations for brain tumours which a few audacious and intelligent men began to perform about 60 years ago. It is very likely that Sir William MacEwan was the first to undertake such a procedure, but traditionally the distinction of having first performed an operation of this kind is accorded to Rickman J. Godlee, a London surgeon, who, on November 25th, 1884, successfully removed a small brain tumour from a young man named Henderson. Little is known about this patient, although, in the words of Wilfred Trotter, the great philosopher and surgeon, he bore "more substantial witness than has yet been produced by any philosopher or any theologian that all suffering is not in vain". From the same writer we learn that "he was young, intelligent, courageous, and he was to die". For although the operation itself was successful, the wound became infected, and after a few anxious and miserable weeks, death from meningitis supervened.

In the years immediately following this event, a number of operations of a similar nature were carried out by various surgeons; but most of them were depressing failures: many of the patients died during or immediately after the operation, and of those who survived this stage, many more died in the course of the next few days or weeks as a consequence of wound infection; even when the operation was "successful" in the sense of not being fatal, the results were often far from gratifying. In those days, access to the brain was usually obtained by boring a small hole in the skull and enlarging it as much as might

be necessary by chipping away the surrounding bone; thus a large, permanent defect in the skull remained, and if the tumour could not be removed completely, its subsequent growth, might and often did lead to a ballooning out of the scalp over the hole, so that in the end the wretched patient, bedridden and revolting, would almost appear to have two heads.

The Work of Harvey Cushing

Such was the unencouraging prospect at the beginning of this century when a young American surgeon named Harvey Cushing decided to devote his life to making the surgery of the brain a practical proposition. To accomplish this task a man of unusual intelligence, manual dexterity and determination was required. Harvey Cushing was such a man: he fully realised the magnitude of the difficulties he had to overcome; and yet he never seems to have doubted that he could and would succeed. In 1901 he asked his chief at the John Hopkins Hospital for a post which would enable him to devote his whole time to this type of work. His chief was staggered, and the hoped-for appointment did not materialise. But Cushing was unabashed: for the next 11 years he continued to work at general surgery and gradually he began to get more and more frequent opportunities of performing brain operations. In these early years his results were little if any better than those of other pioneers, and an operation mortality rate of around 25% attended his efforts. But slowly and steadily his technique improved, and in 1912 he obtained a position of the kind he wanted at the Peter Bent Brigham Hospital in Boston, Massachusetts.

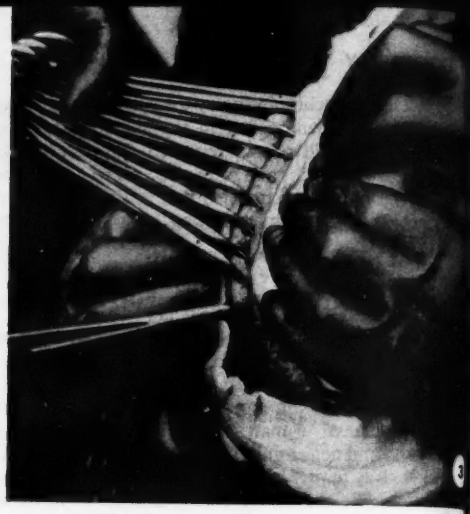
Hardly had he got under way, however, when the war interrupted his career. While working as an army surgeon in France he contracted peripheral neuritis, which permanently impaired his physical activeness. But it took more than ill-health to divert Harvey Cushing from his primary object in life. He returned to Boston after the war, and from then until his retirement from active surgery in 1932 he worked incessantly. Quite soon after the war he began to suffer from a serious arterial disease, and in the end he had to be pushed round the wards and into the operating theatre in a wheel-chair. Nevertheless his results became better and better, and it seems that as time went on he delegated less rather than more of his work to assistants. He tells us that his ambition was to achieve an operation mortality of less than 10% on a year's work, and it must have been a source of immense satisfaction to him to have realised this aim in his last two years, during which the figures were 8% and 5% respectively. It should be noted here that Cushing adopted an extremely rigid standard in assessing operation mortality: any patient who died in hospital after an operation from any cause whatsoever, and no matter how long after the operation, was considered to be an operation death: the results were automatically recorded by a secretary to prevent any possibility of self-deception.

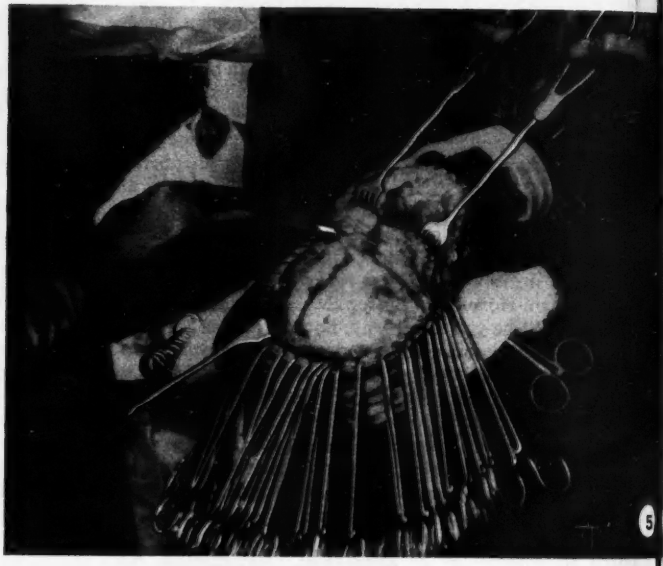
But Cushing was more than a surgeon of unusual technical competence: he made notable contributions to nerve physiology. It was Cushing who first mapped out those parts of the surface of the human brain which are concerned with voluntary movement and with sensation. It was Cushing, too, who first observed the site of formation of the cerebro-spinal fluid (a watery substance produced within the cavities of the brain and passing over its surface and down the spinal cord), though it was his pupil, Weed who completed this research. And it was Cushing whose studies of the working of the pituitary gland led him finally to describe a hitherto unrecognised disease which now bears his name. In recognition of all this work; he was elected a foreign member of the Royal Society, thus becoming one of the very few surgeons who have ever been elevated to that body. He died in 1939, only a few weeks after his admirers had been celebrating his seventieth birthday. By this time his pupils and their pupils were scattered throughout the world, and some of them have already achieved even better results than did Harvey Cushing himself.

Although Cushing made greater contributions to brain surgery than any other single man had done, it is important to recognise that he had distinguished contemporaries who also made notable advances. Otfrid Foerster in Germany was a very important figure. Primarily a nerve physiologist, he had reached the age of 40 before he began to operate on the human brain. In criticism of his work it has been alleged that in dealing with his patients he was more eager to learn something about the working of the brain than to cure their diseases. But although his technical efficiency was never up to that of the best members of the Cushing school, he had many excellent results to his credit. In 1920 he attended Lenin, a circumstance later regarded by supporters of the Nazi regime as a matter for profound regret; his later years (he died in 1941) were clouded as a result of the official disfavour into which he had fallen. De Martel in France was responsible for the general adoption of local anæsthesia in brain surgery. Manipulations of the skull and brain are not painful, and so it is only for cutting through the scalp that measures to relieve pain are necessary. Infiltration with local anæsthetics of that part of the scalp through which the incision is to be made is thus all that is necessary and the dangers of a long-continued general anæsthetic can be avoided. De Martel also introduced the practice of operating on patients in a sitting posture with their heads fixed in position by clamps: this procedure has not generally been adopted.

Diseases of the Brain

In order to understand what modern brain surgeons can do (and also what they cannot do) for patients suffering from brain tumours, it will be necessary to say a few words about the nature of these growths, and of the effects they produce. By a tumour we understand an autonomous growth of tissue, arising *de novo* in some part of the body, growing at the expense of the body and performing no useful function. It is customary to divide tumours into two great classes: benign and malignant. Malignant tumours possess the additional properties of invading surrounding tissues and setting up secondary centres of growth. Many benign tumours, such as ordinary moles and "birth-marks", seldom interfere with health; on the other hand, all malignant tumours are inevitably fatal unless completely removed or destroyed. Brain tumours differ from tumours in other parts of the body in a number of important respects. As they are growing within a rigid box, the skull, whose walls will not expand to any significant





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extent, any considerable increase in size on the part of a tumour necessarily involves compression and destruction of the brain: so all tumours arising within the skull, even the benign ones, are potentially fatal. On the other side of the picture, it is very rare for one of these tumours to set up secondary centres of growth, although some do invade the brain as opposed to simply compressing it.

In view of these considerations it is not surprising to find that brain tumours have two different kinds of effect: some features of a case are due to the increasing pressure within the cavity of the skull; and others are due to irritation or destruction of various parts of the brain. Results of raised pressure include headaches and vomiting of increasing severity, and progressive failure of vision, leading in time to permanent blindness. Irritation of different parts of the brain may lead to fits of all kinds; these may take the form of involuntary movements of some part of the body, or the patient may periodically have attacks of some unpleasant sensation; the fits may or may not be accompanied by loss of consciousness. Destruction of parts of the brain may cause weakness or paralysis of the limbs, clumsiness of movements, loss of the power of speech, defects in the fields of vision, mental deterioration and other unpleasant happenings. So dreadful, indeed, is the outlook for the majority of untreated cases that the earlier workers were less deterred by their high operation mortality rates than they might otherwise have been.

The vast majority of brain tumours fall into one of four large groups. Firstly there are the gliomas, growing from the actual substance of the brain and constituting about half of all brain tumours. Cushing and his colleague Bailey enumerated no fewer than 14 different kinds of glioma; it would be out of place in the present account to describe these in detail, but it may be stated that gliomas range from rapidly growing, destructive tumours inevitably causing death in a matter of months to more slowly growing, relatively benign types where even in untreated cases several years of useful life can be hoped for. Then there are the meningiomas, growing from the coverings of the brain, quite benign, and on the whole offering much the best prospects for operation. The third big group comprises tumours growing from the sheath of the acoustic nerve, which is the nerve which connects the ear with the brain. These acoustic neurinomas, as they are called, usually produce one-sided deafness, weakness of the same side of the face, and severe raised pressure signs. Like the meningiomas they are quite benign, but unfortunately are situated in a part of the brain which is very difficult to get at: consequently the results are not as good as might otherwise be hoped. Fourthly, we have tumours growing from the pituitary gland, which lies underneath the brain. Cushing, at any rate, found these to afford the most favourable results as regards operative mortality, but their complete removal is seldom possible. As they grow very slowly, this does not much matter.

We are now in a position to review the general types of treatment for brain tumours which a surgeon may adopt. Firstly, in the most favourable cases, complete removal of the growth may be carried out. This can be done with many meningiomas and a substantial minority of gliomas. Secondly, partial removal may be performed: in deciding whether to remove the whole or part of any tumour, one has always to consider how much brain substance will have to be destroyed in order to achieve the desired result. This is a problem of a kind which does not arise in the surgical treatment of most tumours. Thus if a patient has a growth of his intestine and if at operation it is found necessary to remove several feet of intestine in order to get the growth away, there is no objection to doing so: no serious disability will ensue. But, unfortunately, one cannot do things like that with the brain. If, to take a contrasting example, we are dealing with a man who has a large and widely penetrating tumour of the left side of his cerebrum (the largest, uppermost part of the brain), he could probably be "cured" completely by removing in its entirety the left half of the cerebrum. If this were done, however, he would be bereft of the power of speech, and his right arm and leg would be completely paralysed and devoid of sensation. He would not even be able to express to the surgeon the disgust which he would presumably feel at the result of the operation. On the other hand, if the tumour were a slowly growing one, partial removal, perhaps repeated later on, would offer a reasonable hope of quite a number of years of useful life. There can be little doubt as to which line of treatment is preferable. A third possible procedure, sometimes useful in the treatment of small, invading tumours, lies in the removal of a fairly large part of the brain containing the tumour, so that only healthy, normal brain is left behind. One of the most surprising things about the way the brain works is that whereas in some parts the removal of a very small piece causes serious consequences, in other parts a large area can be taken away without doing much harm. The extreme front parts of the cerebrum, called the prefrontal lobes, which lie behind the forehead and above the eyes, are like this. You can take away the right or left prefrontal lobe completely and nothing much seems to happen; though if both are removed, serious mental changes set in. Fourthly, if removal of the tumour, even in part, seems to be impracticable, relief from the signs of raised pressure (headaches, vomiting and failure of vision) may be accomplished by what is known as a "decompression" operation, in which a portion of the skull is removed, so that its contents can expand. It is best to remove a fairly large piece of skull and then replace it loosely in position; otherwise, as the early operators found, the contents of the skull will later bulge out in a most unpleasant fashion. Fifthly, X-ray treatment may be combined with either a partial removal or a decompression. Unfortunately, the only type of tumour for which X-rays are of undoubted value is a rather malignant kind of glioma occurring in children, where the inevitably fatal result is usually only put off for a matter of months or at most a year or two.

Up till now this account has been confined to brain tumours, which certainly occupy the greater part of the attention of brain surgeons at any rate in peace time; but there are, of course, other diseases of the brain for which surgical treatment may have much to offer. Brain abscesses were formerly regarded as giving grounds for a very gloomy outlook. Recently, however, it has been found that some kinds of abscesses, when they have been present for a few weeks, develop a tough wall, and can be taken out in their entirety just as if they were tumours. Other conditions in the treatment of which brain surgeons have secured useful results include some kinds of epilepsy, the painful condition of the face known as tic douloureux, in which

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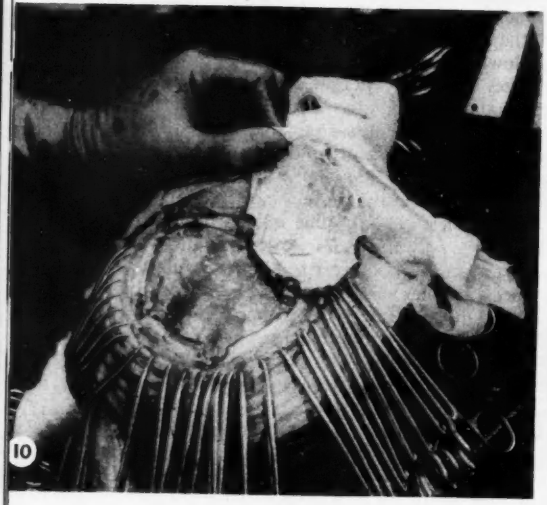

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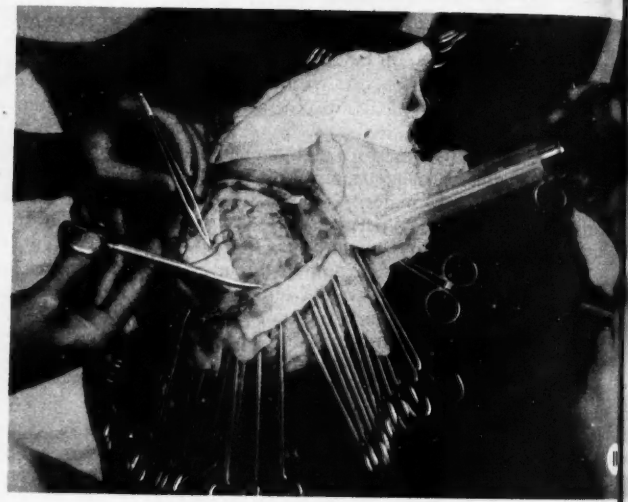

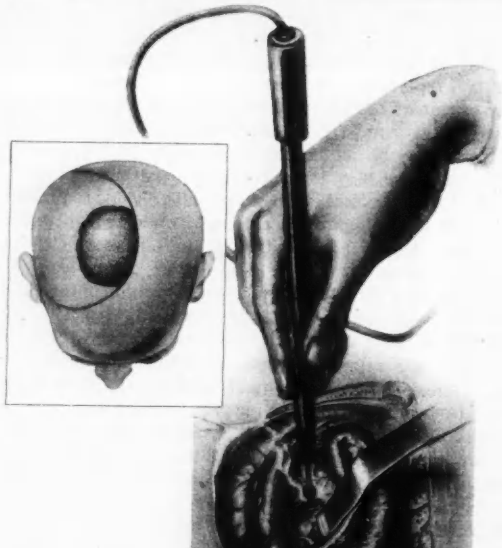

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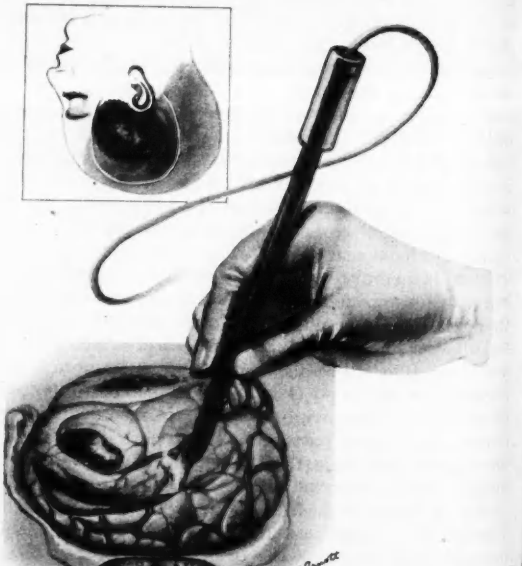

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agonising pains shoot through one side of the face, and various congenital diseases. The treatment of head injuries is another large field: some of the most interesting results in this line have been obtained in the present war and will be described later.

The Surgeon's Work

Probably what most impresses an outsider about operations on the brain as compared with most other operations is the extraordinarily long time which they seem to take. Four hours are usually required for a simple decompression operation, in which nothing is done beyond opening the skull and closing it up again. Six and eight-hour operations are common; ten or twelve-hour ones not excessively rare; and sometimes they last even up to sixteen hours. It is not surprising that brain surgeons tend to get out of the habit of taking lunch! The long time taken, however, is quite essential and is mainly due to the necessity for extreme gentleness in handling brain tissue and the difficulty in controlling bleeding. With regard to this second factor, a vicious circle tends to be set up. The longer the operation is to last, the more imperative it becomes to prevent bleeding; and the greater the care that is taken to prevent it, the more time is consumed. Electrical methods have now come to play an almost indispensible part in the control of bleeding. When a high frequency alternating current is passed through the body by way of two medium-sized electrodes, a moderate sensation of warmth is experienced. But if one of the electrodes is a large wet pad and the other a small metallic point, considerable heat is evolved where the small electrode makes contact, and if such an electrode is applied to a bleeding point, the surrounding tissue is coagulated by the heat, and bleeding stops. Applying the same principle, the small electrode may be made about the size of an ordinary pin: it will then cut through a tissue and coagulate the cut ends of small blood vessels at the same time. The brain may be cut through in this way with a minimum loss of blood in substantially less time than would otherwise be required.

We may now proceed to consider, with the help of illustrations, the steps of an actual operation. Figures 1 to 11 show the principal stages in an operation for exposing an area of the brain towards the front on the right-hand side. The patient, whose head has previously been carefully shaved, is placed on his back on the operating table. The eyes are covered with a piece of gutta percha and the head thoroughly cleaned. Fig. 1 shows the injection of local anæsthetic along the line of the proposed incision through the scalp. When this has been completed, he is carefully covered up with sterile drapings except for the operation area. While the scalp is being cut through, the surgeon's two assistants press with the ends of their fingers on either side of the incision to prevent more than a minimal loss of blood (Fig. 2). With the assistants still pressing firmly, the surgeon next applies a large number of clamps to the deeper parts of the cut edges of the scalp, and these clamps prevent further bleeding, so that the assistants' fingers can be removed (Figs. 3 and 4). In this way, hardly any blood is lost during the opening of the scalp. The incision through the scalp, it will be noticed, is roughly horseshoe shaped, with the open end of the horseshoe downwards. The next step is to separate the piece of scalp within the horseshoe from the underlying skull and fold it back (Fig. 5). A large number of little bleeding points are seen on the inner surface of the folded back scalp, and have to be coagulated electrically before anything further is done. An area of the skull has now been exposed, still covered, however, by a tough membrane known as the pericranium: this membrane is now cut through round the edge of the exposed area of the skull and scraped back, the lowest part, opposite the open end of the original horseshoe, being left intact. There is now an incomplete circle of exposed skull which is next to be penetrated. Five holes, roughly at the points of a regular pentagon, are bored as shown in Figs. 6 and 7. The bone between each adjacent pair of holes except the lowest is sawn through with a special kind of wire saw (Fig. 8). We now have a circular piece of skull which is only connected to the pericranium and scalp along its lower edge. This piece of skull is now levered up (Fig. 9) and cracked back (Fig. 10). All that is now needed to expose the brain is to cut through the tough membrane (called the dura mater) which lies just inside the skull; this has been done in Fig. 11, and the actual brain is at last exposed. Up to this point the procedure is fairly stereotyped, though there are modifications according to the part of the brain which it is desired to expose. (To get at the lower part of the brain at the back, a rather different kind of operation is carried out and a large area of skull is removed completely by chipping it gradually away). Once the brain is reached, the technique adopted varies greatly according to the nature and situation of the tumour involved. The value of electrical coagulating and cutting methods has already been stressed, and Figs. 12 and 13 illustrate their use in the removal of tumours.

On Active Service

So far we have considered the peace-time activities of brain surgeons. We may now turn to a review of their work in time of war. Accounts have recently become available of the way in which they have been applying their skill and experience in the treatment of gunshot wounds of the head. In the British army a number of special units have been organised, each more or less self-contained and possessing sufficient equipment to be able to work at a general hospital or casuality clearing station with no special facilities of its own for this kind of work. Major P. B. Ascroft, the late Major K. C. Eden, and Major J. Schorstein, have commanded units of this type which were in operation in North Africa and the Middle East. A large number of cases passed through the hands of these units, and improvements in their tactical use enabled them to become even more valuable. Major Ascroft's early experience in the Western Desert showed that it was a mistake to try and work in too forward an area. His unit undertook to perform urgent work outside the special field of head wounds, and they found that only 10% of the wounds they treated were head injuries. It was then decided that the units should not in future work in advance of general hospitals. Major Schorstein's unit followed this policy in North Africa and so did the one commanded by Major Eden until after the fall of Benghazi. During the Mareth line battles, however, and the subse-

quent Tunisian campaign, Major Eden divided his unit, leaving part with a general hospital in Tripoli while he himself went forward with the other section to an advanced casualty clearing station. The narrow, bottle-neck lines of communication ensured that nearly all head wounds passed through the hands of one or other part of this split unit. Cases were transported by air from the more forward section to the rear section, and air transport, it seems, may have been an important factor in securing the very good results which this unit achieved. The speed and lack of jolting associated with aerial travel contrast favourably with the conditions obtaining in road or rail transport, and probably this is the most important reason why, contrary to the experience of the last war, it was found that patients could safely be moved two or three days after operation. The results obtained by these three British brain surgeons were essentially similar. With wounds of the scalp and skull which did not penetrate as far as the brain, there was a very low mortality indeed: only three fatalities occurred among 459 cases of this type. Cushing, in 1917, at Passchendaele dealt with 76 such wounds, 6 of his cases dying; but as these 76 were selected from among the more severe cases, the figures are not at all comparable. With wounds which penetrated the brain, the results were, of course, less good: the three units scored 13%, 15% and 24% mortality respectively; even so, such a state of affairs is in marked contrast to the very widespread belief that gunshot wounds of the brain are almost invariably fatal.

One of the most important results of this war-time experience has been to show that the slow, meticulously careful technique employed in dealing with tumours is no less necessary in dealing with wounds of the brain. One of the most serious consequences of a brain wound is a brain abscess, and Major Ascroft found that abscesses were twice as common in patients who had first been operated on by general surgeons as in those dealt with by his team from the start. Good results, however, reward careful treatment of these abscess cases: Major Ascroft had a mortality rate of 25%; in the Soviet Union Bakulov reports a 17% mortality among similar cases treated in a specialised evacuation hospital.

Penicillin, the remarkable new drug obtained from the blue mould Penicillium notatum, was used in 23 of the North African cases. These all had 3-day or older penetrating wounds of the brain, and some already had abscesses; yet only three had died two months later. The results obtained with penicillin in the treatment of these wounds seems to be no less dramatic than with wounds elsewhere, and no doubt when supplies become more readily available, penicillin will play an important part in the routine treatment for injuries of this type.

Cushing in the 1914-1918 war lost 37% of his cases with penetrating brain wounds as a result of infection. At first sight it might seem that a great improvement in technique has taken place since then; but it must not be forgotten that infection acquired in France may very well be a much more serious problem than in North Africa; quite possibly different bacteria in different amounts are involved. Moreover, the only comparable figures from a European battle front in this war are those of Sorgo from Germany, and he reports a mortality of 35%, remarkably close to Cushing's 37%. The solution of this problem is one of the results that may be expected in the near future, when British and American brain surgeons will have an opportunity of playing their part in the forthcoming great battles on the European continent.

DR. LESLIE LAMPITT—*continued from p. 135*

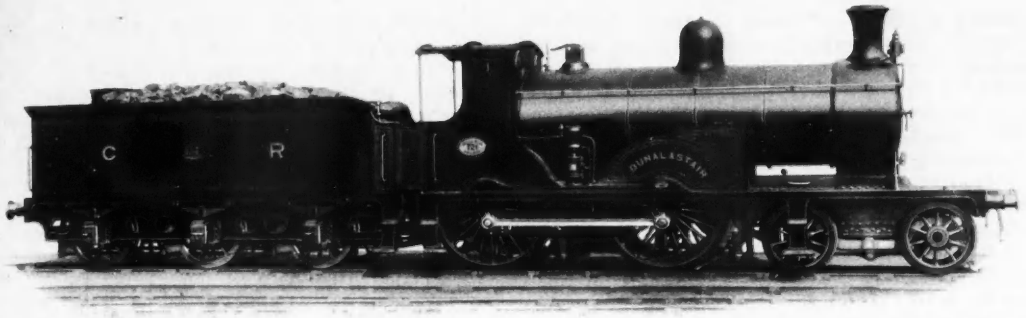
affairs, attending every international chemical congress held since the last war. He is hon. treasurer of the International Union of Chemistry.

His great hobby is amateur theatricals. At the university he was chairman and secretary of the Literary and Dramatic Society. (His co-secretary then was an 18-year old chemistry student, Miss Edith Potts, whom he married a few years later). I might mention that at the age of 18 he was offered a job by Sir Frank Benson, the great Shakespearean actor; it must be unique for a scientist to have had to choose between science and the stage when deciding upon his career! Faultless elocution acquired through his hobby doubtless helps to explain why his speeches, with their witty and ironical turns of phrase, are so much appreciated. His other hobby is gardening; any plant that is new and will grow out-of-doors attracts him, and he has long been a regular subscriber to those botanical expeditions that are sent abroad to collect new species. A keen member of the Church of England, he was a lay reader while he was working in Belgium, and now he performs the duties of vicar's warden at the parish church of St. Mary at Harrow-on-the-Hill.

Dr. and Mrs. Lampitt have one son, who after reading for one year at Oxford volunteered for the Army, was commissioned in the Artillery and served at El Alamein; he is now in Italy.

With all these multifarious activities, Dr. Lampitt still speaks feelingly of the love of pure science instilled into him by the late Professor Brown. He considers that it was probably the fact that Brown was both director of the School of Brewing and professor of Biology and Chemistry of Fermentation that gave him his first insight into the proper alliance of chemistry with industry. His own researches have been mainly concerned with milk and the structure of starch; these he has recorded in the Biochemical Journal. Dr. Lampitt is a realist, not given to erecting theories on hypothetical grounds; it was once said of him that if he stated certain results were obtained in duplicate you could rely that they were really obtained as the result of a dozen experiments at least.

WILLIAM E. DICK.



Courtesy of the L.M.S.

Built in 1896 to the design of J. F. McIntosh, this class of engine performed the work described in this article.

A Scottish Railway Epic

LORD MONKSWELL

DURING the Summer and Autumn of 1896 (July to November) the Caledonian Railway ran a train on its main line from Carlisle to Aberdeen, which, between Carlisle and Forfar, performed work superior to that of any regular train that had up to that time ever run on any railway in the world.

This train stopped at Stirling and Perth. The three stages of 117¾, 33 and 32½ miles were timed to be covered in 125, 35 and 32 minutes respectively. Fairly adequate records of the running were published in *The Engineer*, *Engineering*, *The Railway Magazine* and elsewhere. From these it appears that booked time was usually improved upon, particularly on the Carlisle-Stirling section, where the gain was usually between five and ten minutes.

What makes these feats so remarkable is that the main line of the Caledonian Railway (now the L.M.S.) is almost the most difficult line in Great Britain so far as gradients and service slacks are concerned. Beattock summit, 50 miles from Carlisle and 1,014 ft. above sea-level, lies about 950 ft. higher than Carlisle; in the ten miles between Beattock and Beattock summit the line rises 660 ft. on an average gradient of 1 in 80. Slightly north of Stirling there is a 5½ mile ascent averaging about 1 in 95. In the last 45 miles before Stirling, in the Scottish industrial zone, there are many junctions where speed must be reduced.

For five months the train was run as I have described, and, so far as I know, without the slightest hitch. It was then discontinued and nothing like it was again seen in Gt. Britain till the drastic accelerations of the 1930's. Isolated runs of equal merit were performed from time to time on various lines, but there was, till well after 1930, never again any regular work of the same class.

Overseas Comparisons

The French Nord, which had for some years been renewing its stock of express locomotives, stepped into the breach and right up to the outbreak of war of 1914 provided the best express passenger service in the world, except for certain trains which from 1897 for about 15 years ran, in summer only, between Philadelphia and Atlantic City in America. The only time I travelled by one of these, 58¼ miles were run, start to stop, in 52 mins. 5 sec., and for 41 miles on end the average speed was 80 m.p.h.

So far as Gt. Britain is concerned, the Caledonian train was unique. There is no particular reason for this. As we have seen, the Caledonian road was by no means specially suited for high speed. The permanent way was of no more than ordinary quality. The engines were, indeed, fully equal to the best found on other British lines, particularly as regards steaming power; but, except for blast-pipes of unusual efficiency, they had none of the modern improvements—superheaters, high-pressure steam, passages for the steam giving the utmost possible freedom of flow—which, according to the present Chief Mechanical Engineer of the L.M.S. Ry., are capable of doubling the efficiency of engines built to the designs of the nineteenth century, even when compound cylinders are not employed. It is obvious that, if the Caledonian Railway was able for some months to run a service of the kind described, there was no technical obstacle to prevent all other railways from doing the same. If a railway official had been questioned about this, he would probably have excused himself on the ground of policy. "Policy" is a word that can be made to cover a multitude of sins.

Power Requirements

It may be interesting to estimate as closely as possible the effort developed by the engines which worked these trains. It is equal to the power required to overcome the resistances due to (1) acceleration, (2) gravity and (3) all other hindrances to progress, such as the resistance encountered from the air, from friction in the bearings, from inequalities in the rails and so on. (1) and (2) can

be calculated exactly. (3) varies for many reasons, but long series of experiments carried out in all sorts of conditions have produced results which can be regarded as fairly trustworthy with first-class rolling-stock running over a well-maintained road in average weather.

More accurate estimates of horse-power can be secured by calculating from the work done on rising gradients than from that done elsewhere, for the reason that the resistance of gravity is constant and on rising gradients constitutes a considerable proportion of the total resistance. I will therefore examine the horse-power required to work the Caledonian train over the first 50 miles from Carlisle to Beattock summit. This can be calculated with the more confidence because there seems to have been little difference between the work done one day and that done on another. I will take one of the runs described by the late Mr. Charles Rous-Marten in *The Engineer* of August 21, 1896. The engine weighed 47 tons, the tender (when full) 40 tons and there were 170 tons behind the tender. The train passed Beattock summit at the speed of about 37 m.p.h., 53 mins. 30 sec. after starting from Carlisle (average speed 56 m.p.h.).

With regard to resistance (1), the force required to raise the speed of the train from rest to 37 m.p.h. was sufficient to lift it vertically about 50 ft. As to (2) Beattock summit is about 950 ft. above Carlisle. In respect of resistances (1) and (2), therefore, the engine had to raise the train the equivalent of 1,000 ft. in 50 miles. The average ascent was thus 20 ft. per mile, which gives a resistance of 8½ lb. per ton of train. With regard to the items of resistance grouped under (3) the latest experiments give a resistance of about 35 lb. per ton for the engine and 8 lb. per ton for the rest of the train, including the tender, which works out at an average of 13 lb. per ton of train, the average weight of which (allowing for gradual consumption of fuel and water) was 255 tons. In 1896 the vehicles were smaller than those in use to-day, and the permanent way was somewhat less solid and less elaborately maintained. These things would tend to increase resistance, so it will be safe to add 1½ lb. per ton to the 13 lb. mentioned above. The total average resistance of the whole train between Carlisle and Beattock summit was thus 23 lb. per ton or 875 horse-power, or 18½ horse-power per ton-weight of engine.

Power Limitations

The utmost limit of horse-power per ton of its own weight that any steam locomotive has, up to the present, been known to develop is in the region of 38. The 4—8—0 compound machines of the French Paris-Orleans line, which weigh 108 tons, have on various occasions developed somewhat more than 4,000 horse-power for short periods. In comparison with this 18½ horse-power does not sound much, but it must be remembered that the Paris-Orleans engines have all the latest modern improvements, which enable them in favourable circumstances to utilise for driving the train along the line more than 12% of the energy set free by the combustion of the fuel in the firebox, whereas the design of the Caledonian engines limited them to about 5%. These percentages, no doubt, apply to average efficiencies throughout the whole range of the engines' work—fast non-stop trains, slow stopping trains, a certain amount of shunting etc.,—and they are not necessarily correct when it is desired to compare the work of different engines working express trains. It is quite possible, for instance, that fast non-stop running might have a more favourable effect on an engine of old design, using saturated steam, than on a modern engine, using highly superheated steam, because the more uniform temperature of the cylinders, due to absence of stops, might reduce losses of heat, due to condensation, to a greater extent in the old engine than in the new. And certainly no engine existing, or in sight, could go on for long periods developing 45 horse-power per ton of its own weight, as the Caledonian engine would have done if its efficiency could have been increased from 5% to 12%.

Other contemporary British Timings

Between 1896 and 1930 there was, as already remarked, no regular work performed in Gt. Britain nearly equal to the work of the Caledonian in 1896. Taking speed, gradients and everything into consideration, the nearest approaches were certain timings between Salisbury and Exeter on the L. & S.W. Ry. and between Leicester and Manchester on the Midland. At various periods the run from Salisbury to Exeter (88 miles) was timed to be run in 96 minutes. The gradients are nearly as steep as those of the Caledonian, but not so long; the start is more difficult; the worst bank, that between Axminster and Honiton summit, rises about 420 ft. in 7 miles; there are no service slacks. If this run had regularly been performed in 88 minutes, or rather less, the work might have equalled that of the Caledonian. Nothing of this kind ever appears to have been attempted, and it is extremely doubtful if the 96 min. booked time was often kept. On the Leicester-Manchester section of the Midland, Peak Forest summit (980 ft. above sea) is approached from the south over 15 miles of gradients averaging about 1 in 120—some of which is 1 in 90; and from the north over gradients somewhat longer and steeper. There is also a number of service slacks. These 91 miles were at various periods timed to be covered in 105 minutes. Here again, to equal the performances of the Caledonian, it would have been necessary to achieve 60 m.p.h. start to stop.

During the middle 1930's certain high-speed trains were introduced, which in regard to speed, completely outpaced the Caledonian efforts of 1896. On the last occasion, for instance, on which I travelled by the "Silver Jubilee" the train was stopped by signal opposite mile-post 123 and then ran to King's Cross, start to stop, in 99 mins. 4 secs., at the average speed of 74½ m.p.h. The highest speed reached was about 93 m.p.h.

None of these high-speed trains, however, ran over gradients anything like as steep as those between Carlisle and Forfar. Indeed, in respect of speed over steep gradients, the Caledonian train of 1896 has yet to be equalled by a regular train.

Recent Comparisons

The nearest comparable work in recent years that I can find (and this was a special test performed once only) is that of a 3-cylinder L.M.S. engine between

Carlisle and Ais Gill summit on the Midland main line over the Westmorland moors. Very full particulars were issued by the Railway Company. The engine weighed 80 tons, the tender (full) about 55 tons, and there were 305 tons behind the tender. It will be seen that the proportion between the weight of the engine and that of the whole train was almost exactly the same as in the case of the Caledonian.

Ais Gill summit is 1166 ft. above sea and 48½ miles from Carlisle. These 48½ miles were run in the same number of minutes, but, as there is a service slack just outside Carlisle, it will be fair to call the average speed 61 m.p.h. when comparing it with the Caledonian's 56 m.p.h. to Beattock summit. Speed at Ais Gill was about 46 m.p.h., enough to give a vertical lift of about 80 ft. and Ais Gill summit is about 1100 ft. above Carlisle. So the resistance under (1) and (2) is equal to an ascent of 24 ft. per mile, or rather more than 10 lb. per ton of train. The train was composed of vehicles of modern design, heavier than those in the Caledonian train, and the permanent way was of good modern type. The ordinary table of resistances under (3) may therefore be applied without modification, say 38 lb. per ton for the engine and 8½ lb. per ton for the rest of the train, or rather less than 14 lb. per ton for the whole train. The average weight of the complete train may be taken to have been 435 tons, so the average horse-power developed between Carlisle and Ais Gill summit works out at about 1,700 or 21¼ per ton-weight of engine.

The engine was fitted with many modern improvements, which, no doubt, played their part in reducing the consumption of coal, but it is certainly remarkable that an engine built in 1896 should have been able, in conditions so closely comparable, to develop per ton of its own weight seven-eighths of the horse-power developed by the L.M.S. engine 41 years later, when this latter was doing work far harder than it is usually called upon to do.

I am the last person to belittle the really remarkable spurt in efficiency shown in so many directions by British railways in the years immediately before the outbreak of the present war, and particularly as regards the speed of express trains. But when I look back on the epic I have related, and reflect upon the ruthless manner in which the spirit of enterprise was subsequently for so many years crushed out of existence and upon the loss of time and increase of discomfort thereby unnecessarily caused, I cannot help feeling that this was one of the regrettable cases in which human stupidity was allowed to masquerade in the guise of "policy."

OZONE IN THE AIR—*continued from p.* 143

also at the Meteorological Observatory at Kew (by kind permission of the Director, the late Dr. E. J. W. Whipple), and at the Fernley Observatory, Southport (by kind permission of the Southport Corporation); nitrogen peroxide determinations were carried out at Kew but not at Southport, and the average results are given in the Table below.

Place	*Ozone Content (parts per hundred million)*	*Nitrogen peroxide content (parts per hundred million)*
London	1·3	0·3
Kew	2·4	0·75
Southport	2·3	—

It will be noted that the ozone content of London air is much lower than that of country air, but whilst the former is the average of many experiments the latter are the result of only a few and must therefore be treated with reserve since they are subject to confirmation; it is interesting to note, however, that there is not a sudden increase in the content of the "ozone by the sea".

One of the interesting things brought out by this investigation is the way in which the measurement of very small concentrations or very small quantities makes great demands on the technique and skill of the investigator. In the present case it would have been extremely easy to get some sort of result but it proved a long and painstaking process to get a result of any accuracy which really meant something and might open up avenues *for future investigations.*

As this article was going to press a further paper has been published by Professor Paneth and his collaborators (Gluckauf, Heal, Martin, and Paneth, *Journal of the Chemical Society*, 1944, pp. 1–4) describing a new method for the continuous measurement of the local concentration of atmospheric ozone in which the ozone is titrated electrometrically; this has the very great advantage over the method described above in that continuous determinations can be carried out every few minutes, the results being recorded automatically by a most ingenious device. It is rightly pointed out that the method described above is long and tedious and would only allow one or two determinations to be carried out daily; it is now only used to check the correctness and accuracy of the new method which has superseded it as the natural development in this line of research.

Carnegie United Kingdom Trust

THE report for 1943 of the *Carnegie United Kingdom Trust* records no spectacular development during the year. This is reflected in the grant expenditure which, averaging between £120,000 and £130,000 a year before the War, has fallen to £63,000—the lowest figure reached since the outbreak of hostilities. In one direction at least this is a mark of success. Undertakings assisted in their initial stages have become self-supporting or secured support from local or official sources. Thus, for example, financial responsibility for professional orchestras and opera has been taken over entirely by C.E.M.A., and in future the work of the Trustees will be confined to the amateur field. While continuing their activities in Social Service the Trustees have devoted their deliberations in an increasing degree to the problems of reconstruction. As many voluntary "charitable" and educational bodies have found in the past, the entry of the Government and Local Authorities into the field of social service has made it evident that, in the words of the Chairman's address, "the relationship and allocation of functions between the statutory and voluntary bodies is going to present one of the great problems of the reconstruction period", for to quote his words again, "It is easy to spend money, difficult to spend it wisely".

The Night Sky in June

M. DAVIDSON, D.Sc., F.R.A.S.

The Moon.—Full moon occurs on June 6d. 18h. 58m. U.T., and new moon on June 20d. 17h. 00m. The following conjunctions take place:

June
19d. 13h. Mercury in conjunction with the moon, Mercury 3° N.
24d. 17h. Mars ,, Mars 1° S.
25d. 02h. Jupiter ,, Jupiter 1° S.

The Planets.—Mercury rises at 3h. 11m. and 2h. 58m. at the beginning and middle of June and 8 minutes before sunrise at the end of the month. Venus rises at 3h. 37m., 3h. 06m. and 3h. 53m. at the beginning, middle and end of the month respectively, and is in superior conjunction on June 27. The planet is too close to the sun to be well observed. Mars, in the constellation of Cancer, is a little west and south of γ Cancris at the beginning of the month. The planet sets at 23h. 46m., 23h. 15m. and 22h. 33m. at the beginning, middle and end of the month respectively. Mars is 188 million miles from the earth on June 1 and 207 million miles on June 30. Jupiter, in the constellation of Leo, is a little north west of α Leonis at the end of June. The times of setting of Jupiter at the beginning, middle and end of the month are 0h. 15m., 23h. 24m. and 22h. 30m. respectively. Jupiter's distance from the earth increases from 525 to 561 million miles between June 1 and 30. Saturn sets at 21h. 17m. at the beginning of the month and is difficult to observe as it is drawing too close to the sun.

Some readers of *Discovery* have made enquiries about Uranus. As this planet is a difficult object with the naked eye its position is not usually given. At the beginning of June it lies almost on a line half-way between ε and τ Tauri and could be picked up with a small telescope if it were favourable placed for observation, but unfortunately at the beginning of June it sets before 20h.

As a guide to the positions of Mars and Jupiter, the following information may be helpful. At the beginning of June the bright star Regulus (α Leonis), Jupiter and Mars are nearly on a great circle, Regulus being east and 9° from Jupiter. Produce the great circle twice as far beyond Jupiter as Jupiter is from Regulus, and it passes close to Mars.

Times of rising and setting of the sun and moon are given below, the latitude of Greenwich being assumed:

June	*Sunrise*	*Sunset*
1	3h. 48m.	20h. 08m.
15	3h. 42m.	20h. 19m.
30	3h. 46m.	20h. 21m.
June	*Moonrise*	*Moonset*
1	13h. 58m.	1h. 56m.
15	1h. 20m.	13h. 59m.
30	13h. 55m.	0h. 39m.

Summer Solstice commences on June 21d. 13h. The ecliptic is the sun's apparent annual path on the celestial sphere, and is a great circle inclined at 23° 27′ approximately to the celestial equator. The *equinoxes* are the points on the ecliptic where this circle intersects the celestial equator, and the summer and winter *solstices* are the most northern and most southern point of the ecliptic. The sun attains these positions about June 22 and December 22 but, owing to leap years, the dates vary a little. The inclination of the ecliptic to the equator changes slightly each year; it is decreasing at the rate of 1″ in 128 years.

JUNIOR SCIENCE

Ice and Water

HAVE you ever thought what really happens when a lump of ice melts and turns into water? Both ice and water are made of the same kind of molecules. These molecules, tiny particles which are so small that we cannot see them with our best microscopes, are each built up of two hydrogen atoms and one oxygen atom (H_2O). Ice consists of nothing but H_2O molecules and so does water, but both substances have never-the-less quite different properties. Ice is solid and water is liquid. Since the molecules themselves do not change when ice melts we have to account for the difference in behaviour between ice and water by assuming that the molecules are differently arranged in both cases. And that is actually so.

Fig 1.

In ice, like in most solid substances, the molecules are arranged in a very regular fashion. They stand side by side like soldiers in the ranks. They remain in their positions because they attract each other. However, if heat is supplied to our lump of ice the molecules begin to vibrate, joggling each other all the time. The more they are heated the more they vibrate until finally this vibration becomes stronger than the force with which the molecules attract each other. If this point is reached the molecules in our lump of ice stop holding together and the ice melts.

While it is true that the lump of ice loses its form when melting there is still some cohesion between the water molecules. For instance, a thin trickle of water from a tap breaks up into drops, that means into small lumps of water. This holding together of the molecules which the water has inherited from the ice is strong enough to carry small objects which are actually heavier than the water itself. If you place a steel needle which has been rubbed with oil carefully on water, it will float on the surface. The experiment is best done by placing first a piece of paper on the water and the needle on it (Fig. 1). Once the paper is soaked it can be pushed into the water with a knitting needle while the steel needle remains on the surface (Fig. 2). Observe how the water surface bends under the weight of the needle.

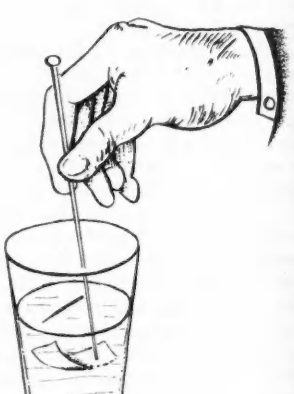


Fig 2.

K.M

The Bookshelf

Simple Experiments in Biology. By Cyril Bibby. (William Heinemann Ltd., 1943; pp. xii + 164; 5*s*.).

THIS book has been published at the right moment. Science has for some time been recognised as a fundamental element of a good general education, and the new educational proposals will lead to an opportunity for a wide application of this principle. One of the valuable aspects of the study of science is the means it gives of introducing schoolchildren to the methods of tackling practical problems; but this aspect only becomes apparent if science is taught (as it so rarely is to-day) as an experimental subject. This book will give invaluable aid to teachers of biology and general science in this connexion. It will be particularly welcome to those many who will soon be teaching these subjects for the first time, and perhaps after a shortened period of training. This is especially the case since there is no other work, known to the reviewer, which gives accounts of really simple experiments, most of which can be carried out with easily obtained material, and which cover the whole field of elementary biology. The author modestly describes his task as "humble and even pedestrian"; but it is neither.

The book is divided into sixteen sections, on such subjects as Biochemical Tests, Soil, Micro-organisms, Enzymes, Circulation in, Animals, Respiration, Growth, the Nervous System. There is a short introduction to each section, defining its subject-matter; then follow very brief accounts of a large number of simple experiments. Zoological experiments are in a marked minority; this is doubtless due, at least partly, to the greater convenience of plants as experimental material. The introduction includes excellent suggestions for the setting out of written results. There is a useful bibliography, a valuable list of sources of material, but no index. Illustrations have unfortunately been omitted on account of the shortage of paper.

Criticism can only be of detail. Inevitably, there are omissions: for example, the simple technique for making a blood smear is not given, although the reader is told at one point to examine human blood under the microscope. Again, among the recommended ways in which reproduction and growth can be studied, the dissection of a pregnant female rat or rabbit is not included. The embryo chick is not given as suitable material for the study of the circulation of the blood.

A more general defect is in the definitions given (or not given) for a number of important terms. The author shows more than once a proper concern that technical terms should be used precisely. In the text, however, mistakes are made in the definitions of "colloid" and "osmotic pressure"; sexual reproduction is said essentially to be a matter of the fusion of two *cells*, instead of (as it should be) two *nuclei;* and there is an explicit refusal, which is quite unnecessary, to define the term "growth". It would perhaps be carping to complain that "unconditional reflex", "conditioned reflex" and "learning" are all used without definition.

But the merits of the book far outweigh these deficiencies. A valuable feature is the way in which the relationship between the physical and the biological sciences is brought out; this is, of course, an almost inevitable consequence of the experimental approach. It is generally agreed that a child's introduction to science should be through general science, and that this subject should not be sharply marked off into such compartments as physics, biology, geology. Many teachers recommend that general science should begin with biology, and that aspects of the physical sciences be introduced from the study of living systems. The experiments described in this book, in particular those on plant and animal physiology and biochemistry, and on the soil, should be of much assistance in applying this principle. Even more important, the practical value of biological knowledge is clearly indicated or implied in many of the experiments, and especially in those relating to agriculture or horticulture.

This book should be in the hands of every teacher of biology or of general science; it could be used to advantage in VIth form teaching as well as in the earlier stages; and it should be available in all school biology libraries, for the use of the pupils themselves. S.A.B.

Man and his Physical World. By Dwight E. Gray. (Chapman & Hall; pp. xii + 665 + 217 ill.; 21*s*.).

THIS book has been written as a textbook of physical science for the use of those American University students whose main subject of study is a non-scientific one. It therefore takes an intermediate place between an ordinary textbook of physics and the usual popular scientific book. The author had before him the difficult task of imparting a great amount of fundamental information on a very large subject of which his readers had little or no previous knowledge. He has attempted to overcome this difficulty by dividing up the field under a number of headings which differ from the classification of the scientific textbook and correspond more closely to a grouping of phenomena as we experience it in daily life. These subjects are then treated in an elementary manner.

On the whole the attempt has met with good success. It is clear that a treatment such as that chosen by the author must lead now and then to small inconsistencies and repetitions. For instance he finds himself discussing the construction and function of the telescope on page 71, where he needs it for the illustration of astronomical observations, while he has to wait until page 536 in order to deal with the general phenomena of light. However, these small and probably unavoidable blemishes are more than balanced by the skilful and easy manner in which the phenomena of the physical world are presented to the reader. Above all, the author succeeds in acquainting the non-scientific reader with the methods employed by the scientist in formulating, approaching and solving a problem. Apart from illustrating the methods of scientific research the author also gives a survey of the more important tools of science. For these reasons the book should have a much wider appeal than to that rather limited circle of readers for which it was originally intended.

The book covers a much wider ground than the ordinary textbook of Physics. It begins with accounts of astrophysics and geology and then deals with the main set of physical phenomena under the headings of Materials, Energy and Applied Science. In the section on Materials not only the properties of matter are discussed but we find in it also descriptions of the technology of the more important substances such as iron, rubber and plastics. Mathematical formulæ have been almost completely avoided. Where they appear, they are exceedingly simple and explanatory words have been used instead of symbols. The book is well illustrated by excellent photographs and simple diagrams.

A feature of the book which is meant to aid the teacher in his task of grading students will probably be greatly welcomed by the general reader. This is the ample sets of questions following each chapter. Two of these sets, multiple choice and true-false statements, provide the most amusing and stimulating scientific quizzes imaginable. Their particular value lies in the fact that, since the book is a textbook no answers to these questions are appended and that there is no other way of finding the correct solution but by a careful study of corresponding chapters.

As is only natural, a book of such wide scope cannot lay claim to be complete. It is, however, astonishing how little of fundamental importance is omitted. The most serious omission appears to be that of aero-dynamics. In all, here is a book that can be warmly recommended to anyone who is keen to obtain a simple but consistent picture of our physical world. K.M.

A Residential Unit for Town and Country Planning. By C. B. Fawcett, B.Litt., D.Sc. (University of London Press; 72 pp.; 3*s*).

DR. FAWCETT outlines a plan for the ideal residential unit in modern society. Hill "vill" would occupy about 125 acres and house between 1,500 and 1,800 people. The relation of this unit to local government activities of the size that will permit of efficient staffing and organisation in, say, education, health and hospitals, sewerage, pipe water, etc., is not quite so effectively worked out as one would desire, but for all that Dr. Fawcett's "vill" should be widely studied. P.V.D.

Far and Near

German Penicillin

GERMAN medical journals received in Britain during the past few months indicate that the Nazis are making some use of the curative properties of penicillin. It is not known how far the German product compares with that prepared in Britain, America and Canada, but the literature reveals that a powder of the same type, though probably not of such high purity, is being utilised and prescribed in doses of the same order as those in practice among the Allies. The publication of the principles of penicillin preparation in British technical journals has been considered for some time to be circumstantial evidence that the Germans already possessed the information passed by British and American censors for publication, and proof that this was the correct view is thus now available. The Germans have not however published many details, which may be taken in either of two ways; either they know less about penicillin, or the German censorship is more severe; the former is more likely to be the case. It is believed that the Germans did not begin penicillin production until at least a year after it was started in Britain and America. Most biological pharmaceuticals such as vaccines as sera produced in Germany have proved on testing by Allied experts, to be far inferior to Allied products; German penicillin may prove to be equally deficient.

Penicillin Film

I.C.I., in conjunction with the Therapeutic Research Corporation, are sponsoring a film about the discovery and development of penicillin for therapeutic purposes. Mr. Alexander Shaw will direct the picture, which in all probability will be distributed by the Ministry of Information. In Britain the film should do much to remove popular misconceptions about this "miracle drug," and abroad it should help to establish —or re-establish—the indisputable though much overshadowed British claim to priority of discovery and medicinal exploitation. Professor Fleming, Professor Florey and Dr. Chain are to collaborate in the making of the picture.

Ukrainian Academy Meeting

A MEETING of the Ukrainian Academy of Sciences, recently held in Moscow, is reported upon in a cable just received from V. Krasilnikov. The meeting was opened by President Academician Alexander Bogomoletz. His opening words expressed gratitude to the Red Army that has liberated a considerable part of the Ukraine and is continuing to sweep the invaders from Soviet territory.

Academician Alexander Palladin, Vice-President of the Academy, reported on the Ukrainian Academy's work in 1943, and outlined the 1944 plan for research work for the Academy's institutions. Various departments and institutes of the Academy, said the Academician in his report, solved a large number of problems of great scientific and practical importance in 1943. The problems connected with the development of metallurgy and power engineering in the eastern parts of the Soviet Union were the main subjects dealt with. Considerable work was also done to rehabilitate economy in districts liberated from the Nazi invaders. Ukrainian scientists are helping in the work of restoring mines and factories in the Donetz Basin and Dnepropetrovsk district, and in the search for new forms of raw material for industry and for building purposes.

"Since the war began," said Palladin, "the anti-reticular cytotoxic serum discovered by Academician Bogomoletz has been widely employed in all hospitals. It has saved thousands of wounded soldiers from death or disablement."

The 1944 plan for work for institutes of the Ukrainian Academy includes 340 general research subjects covering the most important problems with which National economy is faced. Amongst them are problems connected with the restoration of Krivoyrog iron and steel industry, the increase in harvest yield of crops and work of historians and literateurs in the realm of Ukrainian culture.

The session of the Ukrainian Academy also heard a report on the work of various institutes and a number of papers on scientific subjects.

Broadcasts to Schools

THE new term which began on May 1 includes several broadcasts on scientific subjects. This term the broadcasts are designed to interest children in some of the main developments of applied science and the problems and possibilities which they create for the future. Under the general title "Science and the Future" the following broadcasts have been arranged:

May	3	The Home of the Future: New materials and scientific design
,,	10	Building the House: Prefabrication, heating and air-conditioning
,,	17	Planning the Town: Will science help us to solve the problem
,,	24	Air travel and transport: Jet propulsion; stratosphere flight; radio control
,,	31	New Sources of Power: Coal and oil will not last for ever
June	7	A Week-end in the Arctic
,,	14	Food: Full nutrition for all
,,	21	Farms of the Future
,,	28	Health Services for all

The Value of Hoeing

AMONG the many interesting points mentioned in the 34th annual report of the John Innes Horticultural Institution, of which Dr. C. D. Darlington, F.R.S., is director, is a reference to the efficacy of hoeing. Experiments carried out by Mr. J. Newell, assistant curator of the Institution, are described. Two plots of lettuce (Market Favourite) and one of carrot (Scarlet Perfection) were laid out as 3 × 3 Latin squares, the treatments being (1) unweeded, unhoed; (2) hoed weekly; (3) hand-weeded weekly. One crop of lettuce was sown *in situ* on April 1 and caught the worst of the summer drought. The other lettuce crop was sown on August 6, and the carrots on June 19. The results were similar in all three cases. The unweeded, unhoed plots were only half as good as the others owing to the strong growth of weeds, *but there was no significant difference between hoeing and hand-weeding*. The conclusion drawn is that the only effect of hoeing was to remove the weeds, and hoeing, at present, is the most economical way of doing this. The results appear to support the views recently expressed by Dr. Keen of Rothamsted as to the value of hoeing. The theory that hoeing reduces water loss (by evaporation) through altering the physical condition of the soil seems to be losing ground.

Personal Notes

PROFESSOR A. D. ROSS, who occupies the chair of Physics in the University of Western Australia, has been elected president of the Australasian branch of the Institute of Physics. Dr. Ross, a graduate of Glasgow, went to Perth, Australia, in 1912. It was he who suggested the formation of an Australian branch of the Institute of Physics, and for twenty years he has been its secretary and organiser. During the past few years he has been engaged on scientific work for the Commonwealth fighting services.

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DR. ALBERT HOLT TAYLOR, American pioneer of "radar" has been awarded a Medal of Merit by President Roosevelt. Research leading to the development of "radar" (the word stands for "radio detecting and ranging" and is now the standard name for radiolocation throughout the Allied forces), and closely paralleling the experiments of Sir Robert Watson-Watt in Britain, was started by Dr. Taylor as long ago as 1922. Working from his fundamental discoveries research engineers were able, by 1930, to pick up signals reflected from planes passing overhead, and four years later a satisfactory technique for measuring the distance between radar transmitter and the target was perfected. It is interesting to note that the American research in this field was largely concentrated on its potential war-time use; the line of radar evolution did not coincide with the work of Watson-Watt's team, though they both reached a common point of war-time application.

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DR. ISAIAH BOWMAN, president of the American Association for the Advancement of Science, was one of the American mission, headed by Mr. Stettinius, that came to London last month for discussions with the British foreign secretary and other cabinet ministers. Dr. Bowman

is the well-known geographer who was associated with President Wilson when the map of Europe had to be re-drawn after the last war.

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Science and Culture reports the retirement of Dr. WILLIAM BURNS, C.I.E., D.Sc., from the office of Agricultural Commissioner with the Imperial Council of Agricultural Research under the Government of India. A graduate of Edinburgh, Dr. Burns started his career as assistant lecturer to Sir Frederick Keeble, then professor of botany at Reading University. He joined the Indian Agricultural Service in 1908, and was appointed Economic Botanist and Professor of Botany in the College of Agriculture, Poona. It was in 1936 that Dr. Burns became Agricultural Expert to the Indian Government, the title of his appointment being later changed to that of Agricultural Commissioner. His scientific contributions have been mainly in the realms of genetics and the improvement of grass-lands. He was twice elected president of the Indian Society of Plant Breeding and Genetics.

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The Gold Medal of the Society of Antiquaries for distinguished services to archaeology was presented to DR. ROBERT ERIC MORTIMER WHEELER at the anniversary meeting of the society on April 20. Dr. Wheeler is director-general of archaeology in India.

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MR. ARCHIBALD MCVICAR, chief agricultural officer of the Shropshire County Council since 1937, has been appointed principal of the Harper Adams Agricultural College, Newport, in succession to DR. CHARLES CROWTHER, who is retiring.

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DR. C. T. INGOLD is leaving University College, Leicester, to become botany professor at Birkbeck College, London University.

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The death occurred last month (April) of PROFESSOR LIONEL ROBERT WILBERFORCE, who occupied the Lyon Jones chair of physics at Liverpool from 1900 until retirement in 1935. Born in Munich in 1861, eldest son of the late Edward Wilberforce, Master of the Supreme Court, and great grandson of William Wilberforce, he became a foundation scholar of Trinity College, Cambridge. After a period as demonstrator in physics in the Cavendish Laboratory, he was appointed university lecturer in physics at Cambridge. He succeeded Sir Oliver Lodge as professor at Liverpool University College in 1900.

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DR. JOHN KEITH ROBERTS, F.R.S., died in London, on April 28th, at the age of 67. He was assistant director of research in colloid science at Cambridge University. Dr. Roberts, who was born in Australia, was educated at Melbourne and Cambridge Universities, and was demonstrator in physics at Melbourne University. He was assistant in the physics department of the National Physical Laboratory.

THE death of JAMES REID MOIR, F.R.S., which took place on February 24 at the age of 64 years has robbed prehistoric archæology in Great Britain of one of its foremost exponents. It is now over 30 years since Reid Moir first announced to the scientific world that he had discovered in East Anglia, flint implements unquestionably fashioned by the hand of man prior to the Red Crag geological deposits of Suffolk, and thus claimed to have found evidence of the existence of Pliocene man. Henceforth Reid Moir's position in the field of prehistoric archæology was undisputed, even though his work was frequently the storm centre of heated argument. Recognition came to him by election to the Royal Society in 1919 and to the Presidential Chair of more than one learned society. He was awarded the Huxley Memorial Medal of the Royal Anthropological Institute in 1939, and a Civil List Pension was granted him in recognition of his Services to science.

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DR. ERNEST CHARLES SCOTT DICKSON, senior lecturer in Physics at Manchester University, died on April 8. A student of Cambridge and of Bonn (he obtained his Ph.D. at the latter university), he went to Manchester soon after the end of the last war.

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THE death of DR. IDA SMEDLEY-MACLEAN on March 2 is announced. A distinguished biochemist, she was on the staff of the Lister Institute. She was an authority on the chemistry and metabolism of fat, and one of her last publications was a book on this subject in the series of Methuen mono graphs.

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British Union Catalogue of Periodicals

AT the Aslib Conference in November, 1942, following a paper presented by Mr. Theodore Besterman "On a proposed union catalogue of periodicals", Aslib (Association of Special Libraries and Information Bureau) was requested and agreed to consider the possibility of publishing a union catalogue of British and foreign periodical publications on all subjects and of all dates, the location of which is traced in a library in the British Isles. The Aslib Council therefore appointed a special Committee under the Chairmanship of Dr. Luxmoore Newcombe, Librarian of the National Central Library, to consider ways and means of undertaking this project.

The Committee, which included members of the Library Association, the British Museum Staff, the Joint Standing Committee on Library Co-operation and the Science Museum Library, satisfied itself that the project was practicable and that the resulting Catalogue would prove an invaluable bibliographical tool. It was estimated that the compilation of the preliminary check-list, prepared from existing union and other lists and catalogues, would take about five years and that this check-list, in itself, would be of the utmost value.

The project was submitted to the Trustees of the Rockefeller Foundation who have agreed to appropriate, for a period of five years beginning February 1st, 1944, up to £14,000 to Aslib for the British Union Catalogue of Periodicals. Although the work will remain under the financial and general direction of Aslib, the actual operative control of the production of the catalogue will be in the hands of an Executive Council, representative of the leading British library and bibliographical interests. The first meeting of this Council was held on March 28, 1944, when Mr. Theodore Besterman was appointed Editor. Work on the compilation of the check-list will begin at once.

Rubber Plants in China

Two new rubber-bearing plants are being exploited in China, an interesting fact as this opens up the possibility of producing an adequate rubber supply in areas north of the Tropics. The plants are respectively *Ficus pumila* (closely related to *Ficus elastica*, the india-rubber tree) and *Chronomorpha macrophylla*. Both are trailing vines, and both yield rubber from any part of the plant, including the fruit. The *Ficus* plant grows abundantly in the moist regions near and south of the Yangtze River, has a slender stem and grows to 50 feet or more in length. Under acid treatment the latex yields 30% to 50% rubber; average yield per adult plant is one pound of latex, which has a high resin content and a slow curing time. *Chronomorpha* grows in the moist valleys of the wild mountainous region that extends from the south-eastern coast of Kwangtung across the southern part of Kwangsi to the south-western border of Yunnan. The Chinese variety of the plant is larger than that found in southern Asia and the East Indies, with a stem several inches in diameter and numerous branches and shoots that cover a radius of 30 to 40 feet. Growth is rapid, often reaching 10 to 15 feet a year. The rubber content of the latex is 40% to 50% it coagulates in water very rapidly, contains almost no sticky substances and requires no chemical treatment. There are already indications that a rubber industry may develop in China dependent upon these two plants which could be grown very easily on large waste areas eminently suited for their cultivation.

The Naples Zoological Station

THE Royal Society has placed the sum of £1000 at the disposal of the Allied Control Commission to be used for the maintenance of the staff and equipment of the Marine Zoological Station at Naples.

Microscopes Needed for Russia

THE Royal Society for the Prevention of Cruelty to Animals, 105 Jermyn Street, London, W.1, is appealing for gifts of microscopes, urgently needed by Russian veterinary surgeons in their treatment of sick war horses. The Ministry of Supply has approved the launching of this appeal.

Magnesium in Human Physiology

MAGNESIUM in small quantities plays a part in the metabolism of animals. According to a note in *Monthly Science News*, April 1944, the fate of this element in animals—both farm animals and man—has been studied at the Rowett Institute, Aberdeen, by Duckworth, Godden and Warnock. It is found that the amount of magnesium in the blood plasma may be suddenly reduced; the result of so doing may sometimes prove fatal. In severe deficiency, variation in the plasma level of magnesium is apparently paradoxical, since at first it falls sharply and then returns to almost normal levels; it is only after this return that death occurs. It was also found that during a lack of magnesium in the diet the magnesium in the skelton is, to a large extent, liberated to meet the demands of the soft tissues for growth. An interesting conflict arises between tissues in competition for this small supply of magnesium. It seems that while the skeleton liberates magnesium in response to the demands of the growing tissues the skeleton itself remains a competitor and competes with other tissues. If in magnesium deficiency the growth of the skeleton is simultaneously checked by withholding calcium from the animal while about the same amount of magnesium is liberated there is no new formation of bone to claim its share; the animal then lives several times as long as when the skeleton continues to increase in size. Poorer sections of the community seem to lack adequate amounts of magnesium for growth and maintenance. This may be an important factor in the case of heavy workers, especially miners, whose sweat losses are high; these losses represent a material loss of magnesium. It may also be of importance in the Tropics.

Nematodes in Lambs

DURING the past few years many reports have been published on the use of phenothiazine as an anthelmintic. Different criteria have been used by different workers to assess its efficacy, and, having regard to the fact that the published reports contained certain discrepancies, the Agricultural Research Council instituted a series of co-ordinated experiments at several centres. These experiments were so planned as to be capable of statistical analysis and to give answers to specific questions. The results from these investigations and the conclusions drawn from them are now presented in a report entitled *Co-ordinated Trials with Phenothiazine against Nematodes in Lambs*, which has been published at 3*s*. 6*d*. for the Agricultural Research Council by the Executive Council of the Imperial Agricultural Bureau.

This report is interesting, not only for the results obtained, but also for the extent to which existing statistical procedures were applied to a problem of agricultural research.

Bogomoletz's Serum

The Presidium of the Supreme Soviet of the U.S.S.R. recently awarded the title of Hero of Socialist Labour to Alexander Bogomoletz, President of the Academy of Sciences of the Ukraine. This act was an acknowledgment of the valuable services this scientist has rendered. He has become world-famous for the serum, popularly called the "Bogomoletz serum", which represents the fruit of his extensive researches in biology and especially of his theory of connective tissue and the part it plays in living organisms. DISCOVERY, has received from E. Finn an account of an interview he had with Professor Bogomoletz, who described the nature of the serum. "The origin of a disease," he says, "its course and favourable or unfavourable issue depends not only upon the external factors which give rise to the disease, but also upon the power of resistance of the organism. That, of course, is now common knowledge. But from this it follows that the health of an organism, its longevity, its resistance to disease, as well as the healing of wounds and fractures depend upon the physiological state of the organism, and especially upon the reactivity of the cells of the connective tissue. This latter point is of immense importance."

It took almost 20 years to elucidate the functions of the physiological system of connective tissue. Towards the end of the last century Metchnikov pointed out the protective function of phagocytes of the blood (blood is a form of connective tissue) in helping the organism to resist microbes, but it was some time before the importance of that discovery was recognised. The regenerative function of connective tissue, as evidenced in the healing of wounds or ulcers or when the growth of new cells of the connective tissue forms a callus which binds together the ends of the broken bone its more difficult to explain. Of immense importance, too, is the trophic function of connective tissue, which regulates the flow of substances between the tissues and the blood. Disturbances of this function may lead to the premature senility of the organism. "And so," states Professor Bogomoletz, "we know the functions of the connective tissue and its reaction to infections, wounds, growths, tumours, etc. Naturally, the question then arose of regulating this power of reaction and, if necessary, of enhancing it."

After long years of research, Bogomoletz and his pupils found a solution to this problem. They prepared a special serum which they named anti-reticular cytotoxic serum. Professor Bogomoletz explains how it was obtained. Several successive injections are made beneath the skin of a horse of cells of the connecting tissue of the spleen and bone marrow taken from a dead human body. The blood of a horse so treated acquires the power of depressing in large doses and enhancing in small doses all the physiological functions system of human connective tissue.

Prior to the war the effectiveness of this serum was demonstrated in a number of cases, particularly in preventing a recurrence of cancer after operation. Extensive laboratory and clinical experiments were carried out by Doctor Oleg Bogomoletz, the academician's son and assistant, in that field. On the outbreak of the war Bogomoletz took measures to secure the wide use of the serum in the healing of wounds. In spite of war-time difficulties due to the evacuation of his laboratory and the lack of scientists—many scientific workers were fighting at the front—the serum began to be manufactured in ever-increasing quantities. To-day the serum is being employed on a wide scale in military and civilian hospitals. It has been proved that, when the proper procedure is observed, the serum is highly effective in shortening the course of infectious diseases and promoting recovery, and also in expediting the healing of wounds and fractures. There have been many striking cases of fractures which refused to heal, but which, after subcutaneous injections of only one drop of the serum, thrice-repeated, healed within five or six weeks. Many amputations have been avoided by its use.

Professor Bogomoletz believes the serum will be widely used for the cure of a number of acute and chronic infections, to prevent the recurrence of cancer after removal, and for healing diseases which cause premature senility of organisms, such as high blood pressure and the early development of sclerosis.

The Royal Chemical Society

ROYAL Chemical Society was held at Burlington House, London, on April 20. During the business portion of the meeting, Professor W. N. Haworth, D.Sc., F.R.S., Nobel Laureate, was elected President, and Mr. E. J. Bowen, M.A., F.R.S., a Vice-President. It was also announced that Dr. M. P. Applebey, Dr. M. P. Balfe, Dr. L. Hunter, Dr. E. R. H. Jones had been elected ordinary members of Council.

Institute of Physics: Inauguration of Scottish Branch

PHYSICISTS employed in industry in Scotland have for some time felt the need of local opportunities for the interchange of knowledge and experience of applied physics. At their request the Board of the Institute of Physics has therefore authorised the formation of a Scottish branch of the Institute, which is to be centred in Glasgow.

Further particulars of the branch may be obtained from the Acting Honorary Secretary, Dr. R. S. Silver, F.Inst.P., c/o G. and J. Weir, Ltd., Cathcart, Glasgow, S.4.

Royal Astronomical Society

THE following were elected officers of the Royal Astronomical Society at the annual meeting: *President*, Professor E. A. Milne; *Treasurer*, Mr. J. H. Reynolds; *Secretaries*, Dr. H. R. Hulme, Mr. D. H. Sadler; *Foreign Secretary*, Sir Arthur Eddington.

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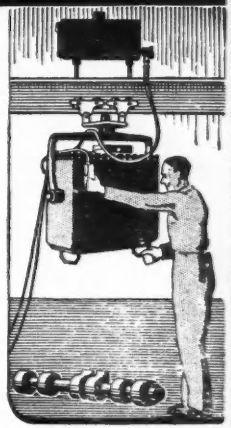

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YELLOW RIVER

NOT the Yellow River of China — just any one of the many 'yellow' rivers of the Tropics. Man has always settled as near water as possible. To him it has meant life, and it is due to this instinctive reasoning that many rivers have been venerated as gods — Father Tiber and Mother Ganges — arbiters of life and death. The peoples who dwelt on their banks had no means of realizing that the same waters from which they drew their life brought also death, killing them in their thousands because they or their animals polluted them with the bacteria of cholera, dysentery, typhoid and other plague-causing diseases. Even in Europe and America, amid all the amenities of peacetime civilization, river and stream waters threaten the lives of millions of dwellers in the great cities. Fearful epidemics may be caused by infected drinking water. Diseases may be spread by contaminated swimming-baths. More than ever today do these dangers threaten the health of man, woman and child.

Luckily the British chemist has developed weapons with which to meet them, particularly in the use of chlorine for the sterilization of water. Credit for its first systematic use for this purpose is due to the late Sir Alexander Houston who employed hypochlorite during a severe epidemic of typhoid at Lincoln in 1904. His successful treatment attracted attention all over the world. Later the use of chlorine gas in place of hypochlorite solutions was developed. This is the method mostly favoured nowadays. Chlorination is particularly valuable for troops in the field and in areas where the water supply has become contaminated through enemy action. The British chemist is constantly at work improving methods for maintaining the health of the nation by ensuring that its water supplies are safe. The British chemical industry — the first in the world to manufacture chlorine upon a commercial scale—can be relied upon to provide an adequate supply of both chlorine and hypochlorites.

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